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THE JOURNAL OF WILDLIFE MANAGEMENT

VOLUME 21 JULY 1957 NUMBER 3

FUR PRODUCTION OF THE BOREAL FOREST REGION OF BRITISH COLUMBIA[1]

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Since earliest historical times, fur-bearing animals have constituted an important part of the natural resources of Canada. Eighty per cent of Canadian territory is still in the phase of land use where primary resources are of first importance. Thus it is that the fur harvest remains a vital source of income to about 47,000 trappers, native and white. The fur yield varies across Canada, but in 1950-51 it averaged $13 per square mile in Manitoba and Ontario, and at this level was the most important source of wealth on much of the wild lands of these provinces (Cowan, 1955).

Despite the importance of the fur resource there is, with few exceptions, almost no information on the ecological requirements of fur species, on the densities the species achieve, or on the yield they can supply in the different ecological regions that they inhabit.

The registered trap-line (= trapping-area) system was developed in British Columbia and has been in full operation here since 1929 (Eklund, 1946). In brief the system consists of allocating to each trapper the sole right to trap on a defined area. Trappers, Indians excepted, are required to submit annually a statement of the animals taken from their lines. These accumulated reports now constitute a unique body of data on fur animals in western Canada. This paper is the first of a proposed series using these data to study fur production and fur management in the various and diversified ecological regions of British Columbia.

The present study deals with fur production in the boreal forest region of northern British Columbia as delineated by Halliday (1937). Fig. 1 outlines the region, which comprises 67,200 square miles on which 310 trappers hold registered trap lines. The 164 trap lines selected for detailed study have a mean area of 144 square miles each. They were selected solely on the basis of continuity of record, but even on these, changes in ownership and in methods of record-keeping provide continuous comparable records for only an average period of 10.8 years.

This is a spatial rather than a temporal study, with production for different subregions calculated for the same span of years. Thus temporal influences on trapping effort, such as changing prices of fur, are not of importance in influencing the relative productions from the seven forest subregions studied. The same may probably be said for cycles. In production figures calculated for any period of years, variations in the population density of the important species will influence the average annual production levels, but in examining relative differences in production between adjacent areas of limited size cyclic changes in abundance are of less importance.

In this study, cycles have been largely ignored except for our having established that each of the species most subject to violent fluctuations increased and declined more or less synchronously throughout the boreal forest.

The few other studies of fur production on designated ecological regions are for one reason or another not comparable to the present one. Quick (1953) studied some trap lines about Fort Nelson; these lines are included in our data. Hess (1946) reported

[1] The authors express appreciation to F. R. Butler, Game Commissioner, B.C. Game Department, for permission to use data and for assistance in compiling them.

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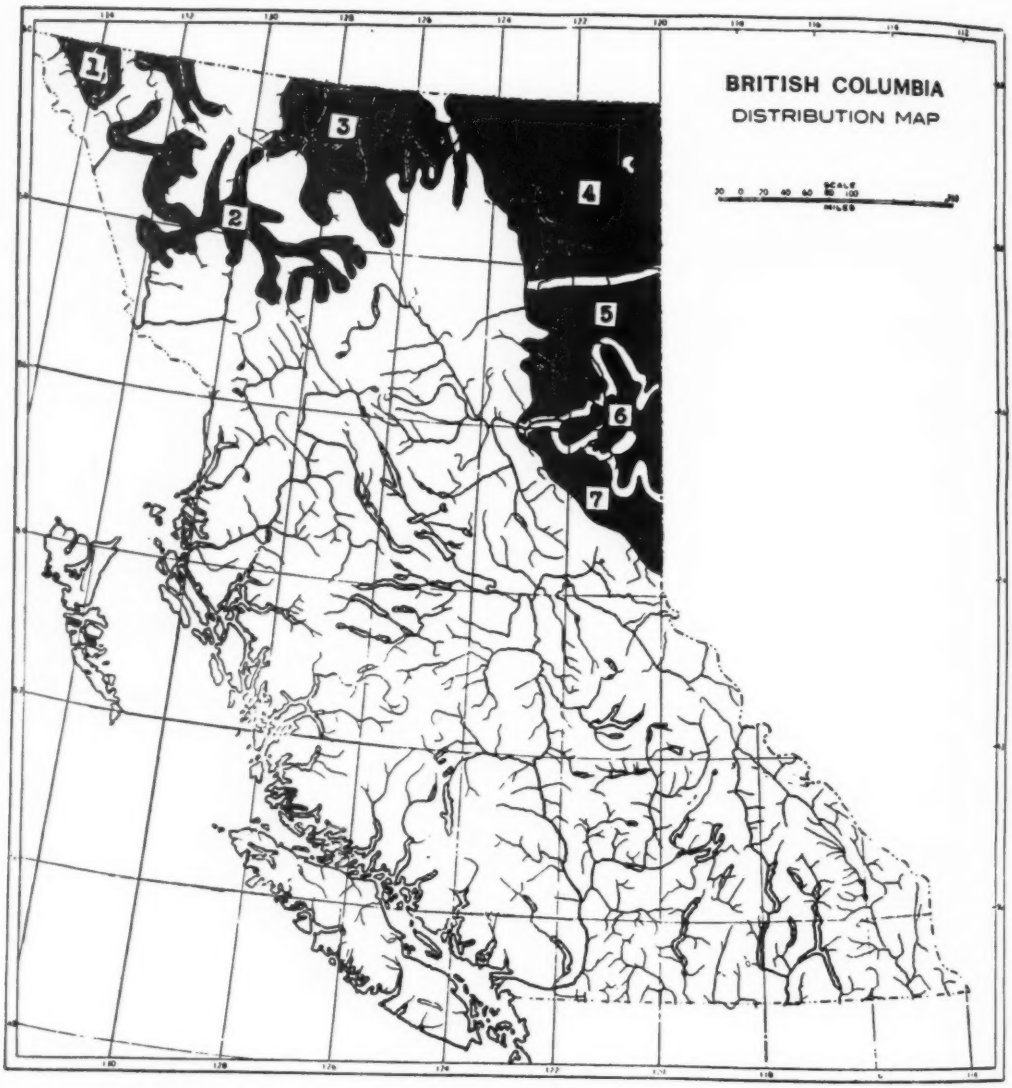

FIG. 1. Extent of the boreal forest in British Columbia. Numbered subregions are: 1—Yukon; 2—Stikine; 3—Liard; 4—Nelson; 5—Northern Peace; 6—Peace Parkland; 7—Southern Peace (after Halliday, 1937).

on the catch from one Ontario clay belt trap line over 14 years. In both instances the areas studied were so small that human activity on surrounding areas could exert a powerful influence. Peterson and Crichton (1949) studied fur production on a small part of central Ontario but it is difficult to compare their data with ours.

STUDY METHODS

The annual catch reports from 1929 to 1948 inclusive constitute the basic data for this study. As part of its trap-line control system, the Provincial Game Commission maintains maps of all lines, and it is these that have permitted our calculation of trap-line areas and corresponding yield.

We have calculated productivity for each species in the form of average number of square miles that produced one pelt per annum.

In this way yield on the seven different areas included in the boreal forest region of British Columbia can be compared. There is unfortunately no way as yet to relate such productivity figures to theoretical maximum yield or directly to the size of the population being exploited.

The boreal forest region of British Columbia is not uniform in its ecological characteristics and can be divided into seven areas differing in vegetation, altitude, drainage characteristics, proximity to alpine or grassland conditions, the extent of burned areas, the abundance of man and his works, and other factors.

When one considers these factors over so large an area, it is the broad picture that is most important. Localized personal experience can be misleading, as exemplified in certain conclusions reached by Quick (*op. cit.*) that are at variance with the over-all situation. Most of our data on ecological conditions have been drawn from the physiographic surveys of Bostock (1948), various geological surveys (Camsell, 1936; Dawson, 1881, 1898; Johnston, 1926; McConnell [in Dawson, 1898]; and Watson and Mathews, 1944), the forest classification of Halliday (1937), and unpublished forest surveys undertaken by the British Columbia Forest Service, particularly those by A. E. Collins; and the 1941 census of Canada undertaken by the Dominion Bureau of Statistics (Anon., 1944).

DESCRIPTION OF THE AREA

For the boreal forest region of British Columbia the characteristic vegetation occurs from river bottom to timberline. In its climax form, trees are mainly white spruce (*Picea glauca*), black spruce (*P. mariana*), and balsam fir (*Abies balsamea*). Periodic fires, often extensive, appear to be natural phenomena, and result in seral forest areas as a normal feature of most parts of the region. Seral stages feature aspen (*Populus tremuloides*) and white birch (*Betula papyrifera*) with lodgepole pine (*Pinus contorta*) replacing the jack pine (*P. banksiana*) that is found throughout this forest elsewhere in Canada.

Five major river systems drain this part of the province, the Yukon and its tributaries, the Stikine and Taku, the Liard and the Peace.

Physiographically the region falls into two main systems, the Cordilleran and the Great Plains (Moore, 1944). In the former the boreal forest is confined to the lowest elevations of three plateaux. The Yukon and Stikine plateaux, both of high elevation, and the Liard Plain, of lower elevation, lie west of the Rocky Mountains. East of these the forested extension northward of the Great Plains covers the entire area.

Within the boreal forest seven subregions can be recognized on the basis of physiography and vegetation (Fig. 1); these are as follows.

The Yukon forest subregion, restricted in size and confined to the lowest elevations of valleys, drains the Yukon plateau. This plateau is a much-eroded and treeless tableland, with an elevation of about 5,000 feet. Tree line is at approximately 3,800 feet. Numerous lakes characterize the area, some of them large. The weather is dry in the rain shadow of the Coast Mountains, records from Atlin indicating an average annual precipitation of only 11 inches. Generally speaking, the forest is stunted and open, with extensive burns forming seral forests of aspen with abundant grasses.

The Stikine forest is similar and confined to valleys in the extensive, treeless Stikine plateau with an elevation of about 4,000 feet. Burns are large and numerous, particularly in the west. This plateau is less eroded than the Yukon plateau, its valleys are narrower and lakes less numerous except for a restricted area to the northeast near Dease Lake. The top of the plateau itself, above tree line, is boggier than the more eroded plateau to the north.

The Liard forest covers the intermountain Liard plain, an area with little relief, and with all elevations lying below 3,000 feet. Large poorly drained areas have bogs and muskegs, while drier sites, particularly to the west and near the Cassiar Mountains, are frequently burned and support grasslands or aspen forests as a result.

The Nelson forest covers the Liard drainage on the Great Plains. This forest is little influenced by alpine conditions, a feature variously characterizing the boreal forest within the Cordillera. Since the mountains to the west of this forest are relatively low, this is the most humid of the seven forests. Drainage is poor, with muskeg extensive and lakes abundant. Drier sites are frequently burned.

The Northern Peace forest resembles the Nelson forest, except that it is better drained; a relatively larger area is subject to foothill topography. Southern portions are influenced vegetationally by the Peace parkland to the south.

The Peace parkland is the most isolated from alpine and subalpine conditions of the seven forests. It is characterized by grassy aspen parklands, pockets of rich agricultural soil, and elevations ranging from 1,800 to 2,400 feet. Logging has removed much of the original coniferous forests, and large areas of burn are common.

The Southern Peace forest resembles the coniferous forests to the north, except that from its smaller size it is most influenced by foothill topography, is better drained and includes a more influential intrusion of the grassland conditions that reach fullest expression in the parklands.

The influence of humans throughout the boreal forest has not been uniform. Agricultural soils in the Peace parklands have attracted the densest human population in northern British Columbia. Here agriculture and logging have changed the natural vegetation; similar influences are penetrating both the North and South Peace forests, particularly the latter. Human influence has been unimportant in the Cordilleran areas except for the highway along the Liard valley, and mining activity near Atlin. However, mineral exploration is intensifying, and major discoveries may further affect the area.

FUR PRODUCTION

For the purpose of discussion of fur yields, we assume that the economic motive to trap has been equally operative throughout the region and therefore that yield figures from one subregion to another reflect to some close degree the population of fur bearers available.

The yields of each of the twelve species of fur-bearing mammals occurring as regular inhabitants are shown in Fig. 2. Each graph compares one species through the seven subregions. In interpreting the graphs, it must be remembered that the shortest columns represent the highest yields.

Several species are not included in the graphic treatment. Striped skunk (*Mephitis mephitis*), raccoon (*Procyon lotor*), and cougar (*Felis concolor*) are occasionally taken adjacent to the Peace River, but are beyond their normal range. The otter (*Lutra canadensis*) occurs regularly but in small numbers in 6 of the 7 subregions. The average number of square miles per otter pelt in subregional order 1 to 7 is 1,783, 1,298, 1,334, 1,526, 4,385, nil, 3,029. It is the rarest of the indigenous fur bearers throughout northwestern North America.

The yield densities illustrated show considerable variation from species to species, and from area to area, but despite this there are manifest tendencies for groups of species to be associated in yield. Thus, areas with a high muskrat (*Ondatra zibethica*) yield also have a high weasel (*Mustela* spp.) yield; red squirrel (*Tamiasciurus hudsonicus*) also falls into this association with the exception of the Stikine forest. The figures for coyote (*Canis latrans*) and wolf (*C. lupus*) are somewhat alike in trend and conform to the pattern of weasel and muskrat. There are notable differences, however, such as the low yield of coyote in the Nelson forest.

The remaining seven species, plus the otter, differ in trend from the five already mentioned. The relatively poor production in the Peace parklands of otter, beaver (*Castor canadensis*), mink (*Mustela vison*), marten (*Martes americana*), lynx (*Lynx canadensis*), and wolverine (*Gulo luscus*) is marked. Similarly the highest production of beaver, marten, lynx, and fox (*Vulpes fulva*) is reached in the Nelson forest.

Another general observation is that yield in the mountain areas is markedly lower than it is in the forested plains.

In two species there are almost "clinal" trends in yield. Wolverine shows an almost constant decrease from northwest to south-

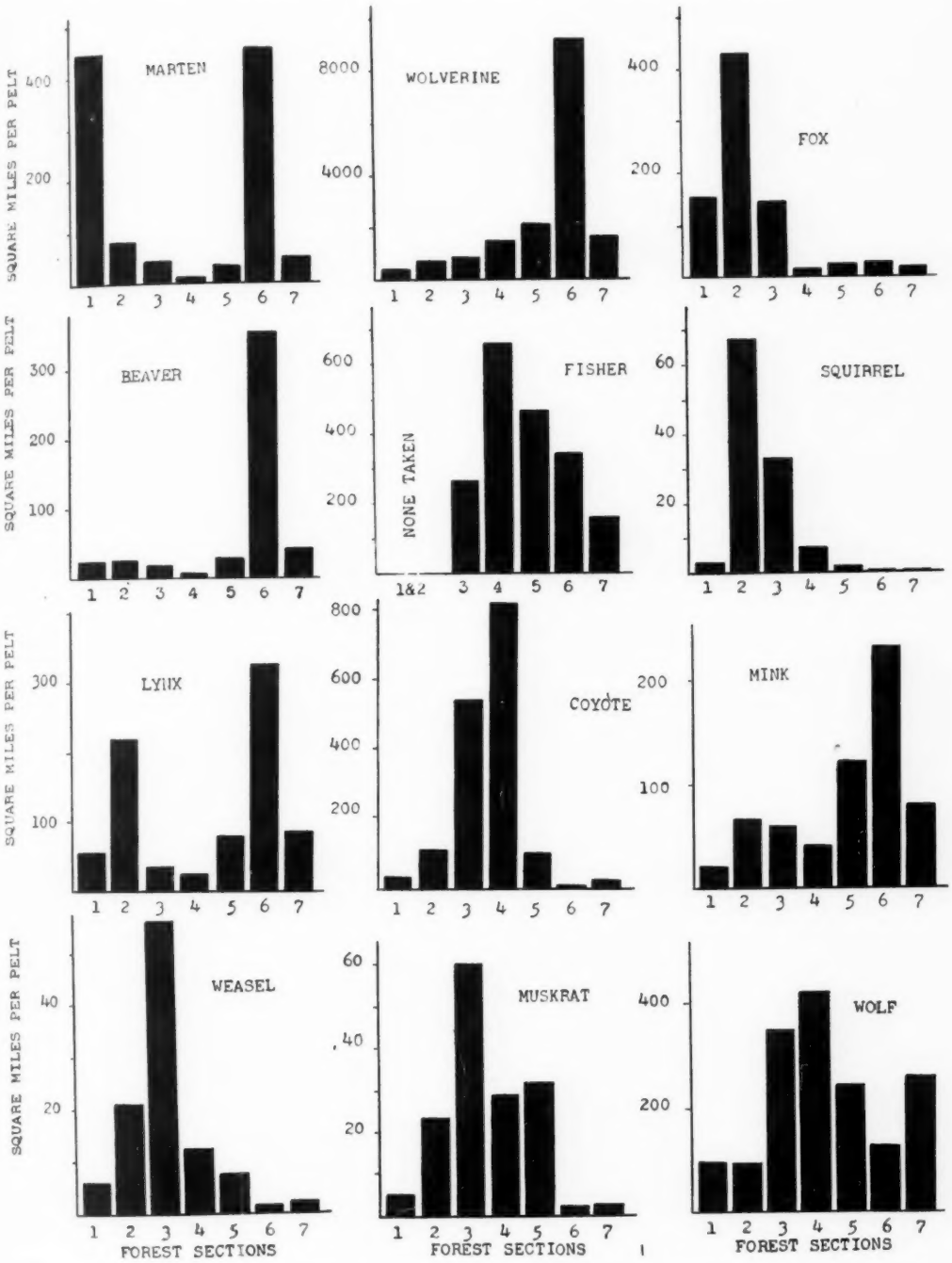

FIG. 2. Yields of 12 species of fur-bearing mammals in seven subregions of the boreal forest.

east. Fisher (*Martes pennanti*) appears to be absent from the Yukon and Stikine forests and becomes progressively more abundant from north to south on the plains.

ANALYSIS AND DISCUSSION

Several factors influence the fur yield taken from any region. Of first importance is the stock available to the trapper and it is this that is of the most interest to us in the present study. Another highly important factor is incentive to trap. This can be applied either as a high price for the catch or as reduced alternative methods of obtaining financial return for labour.

Innis (1927), in his study of the economics of the fur trade in Canada, suggests that fur species may be divided into two categories, fine fur and coarse fur. According to him fine fur, such as fox or marten, has high value and fluctuating supply and is sought up to the limits of availability. Coarse fur, as muskrat and wolf, has low value per pelt and consequently is neglected where fine fur is abundant. It should be pointed out also that the majority of the so-called coarse-fur species are either of high ecological tolerance, or are associated with disturbed or seral stages of the forest, or with rich-land environments such as marshes.

Fine-fur Species

Innis (*ibid.*) recognizes as a characteristic of fine fur that production is proportional to the abundance of the species concerned, and is not appreciably affected by changing economic conditions. This appears to have been true for a long period in the trapping history of Canada, and is accepted as true by the many authors who have contributed to the extensive literature concerning cycles in fur-bearing mammals.

It is apparent from field experience with large trap lines in several parts of British Columbia that, prior to about 1950, this was an acceptable rule in most cases. Fine fur was taken as available if there was any trapping at all. Since that date the price of fur has been exceptionally low, so low in fact that it appears to have created a situation unique in Canada's history of fur production. In the past few years many trappers have not trapped at all. The low financial return from trapping is not enough to justify the effort. A general condition of poverty has spread across many parts of Canada where fur was formerly a major product with no other important means of income available. No such period of low fur demand has influenced the period under study.

The distinction between coarse- and fine-fur species is a most important one because from it follows the inference that the yield of fine fur will closely parallel availability, whereas this will only be true of the species of low value where more valuable species are scarce or absent.

From Fig. 2 it can be seen that those species falling into the coarse-fur category, wolf, coyote, weasel, red squirrel and muskrat, show high yields in the Peace River forests where mink, marten, beaver, and lynx are low. They are high also in those plateau forests of the northwest where production of fox, lynx, marten, and fisher is low. Conversely, areas with high yields of fine fur usually have low coarse-fur yields.

However, another factor enters. Fig. 3 shows the average trap "line" area for each

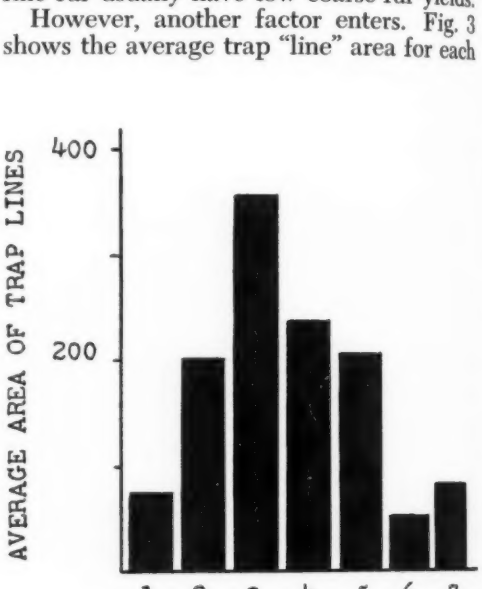

FIG. 3. Average size in square miles of trapping areas in seven subregions of the boreal forest.

of the seven forest subregions. There is strong negative correlation between the yields of the five coarse-fur species and trap-line size. That is, coarse-fur production is high where trap-line size is small. The coefficients of correlation (using "sq. miles per pelt," hence positive correlations) and

probabilities resulting from "t" tests (Goulden, 1939) are: muskrat r = 0.987 with P less than 0.01; weasel r = 0.821, P = 0.02; red squirrel (omitting Stikine forest) r = 0.864, P less than 0.01; coyote r = 0.701, P = 0.05; and wolf r = 0.754, P = 0.02.

These figures strongly suggest that trap-line size has a major influence upon the production of coarse furs. Small trap lines produce a higher yield per unit area, while large trap lines are low producers.

The influences affecting trap-line area are several but the most important appears to be that of demand for space in which to trap. In northern British Columbia the smallest trapping areas are found in and about the regions containing the most people. A system of registering the boundaries will tend to oppose this trend toward smaller lines with an increase of human population. However, in British Columbia most lines were registered after supply and demand had already established a pattern of trapping-area size.

The pattern of fur yield on the areas producing primarily coarse furs is the result of influences that may be summarized as follows. Agriculture and lumbering may have altered the area so as to render it unsuitable for the fine-fur species; at the same time intensive trapping upon the smaller trap lines may have depleted those species with an inherently low density.

If this interpretation is correct, it follows that coarse-fur species are more or less ignored on the larger trapping areas where fine fur is available. The continuance of high per-unit-area yields of coarse fur even on the smallest areas also implies that these fur species are inherently highly productive and that trapping is unlikely to reduce productivity over a period of years. This is to say that careful management is less important for these species than it is for the species of lower density that have proven vulnerable to reduction through human influence.

We have observed that the first of these implications is correct. Where marten, lynx, and fisher are available in numbers, trappers may not bother with lower-priced species. However, it is worth remarking that elsewhere in Canada there are areas of especially high muskrat production where this species is preferred over all others because ease of capture and abundance make it profitable to concentrate on it even when fine fur is present.

Thus, in northern British Columbia the factors influencing coarse-fur production seem to be those affecting the efficiency with which an area is harvested. In a sense these are often more economic than biological.

It is self evident that while the factors described above may set the stage for high coarse-fur production, if a species is scarce its production will be low. This is believed to be the situation with respect to the squirrel yield in the Stikine forest where several other species, including lynx, fox, and marten, are also scarce.

Some significant facts on relative densities can be derived from comparison of the yields of the different fine-fur species on the seven forest areas.

Wolverine. Innis (*op. cit.*) considers this to be a coarse-fur species. However, in northern British Columbia its production is more like that of the fine furs. Its fur is in high demand for trimming outdoor clothing and this, along with the wolverine's reputation for destructiveness on trap lines, leads to intensive trapping effort. Its fur yield is probably a close reflection of population density.

Fig. 2 illustrates decreased density from northwest to southeast with near absence from the Peace parklands. Several authors describe the wolverine as being most abundant in alpine and subalpine areas (Dixon, 1938; Grinnell, *et al.*, 1937), and Clarke (1940) records it far out on the Arctic barrens. Unpublished studies in Wells Gray Park, British Columbia, reveal it as a timberline species in summer but frequently encountered in adjacent forested valleys in winter. This habitat preference agrees well with its fur production. It has highest production on the high, cold plateaux in the northwest (236 and 352 square miles per pelt), lower production in the mountain-encircled Liard forest (426 square miles), and still lower production on the forested plains east of the mountains (697 to 9,232 square miles). Proximity to mountains seems to increase production, a point on which we disagree with Quick (1953). This was further tested by calcula-

ting production for the four areas bounded by meridians of longitude on the forested plains and north of the Peace River. The numbers of square miles required to produce one pelt were from west to east 741, 932, 1,003, and 4,244. This shows that, while wolverine production upon the forested plains is relatively low, it is highest in the west next to the mountains and becomes progressively lower with increased distance from them.

Marten. Lowest yields, approximately 450 square miles per pelt, are found in the Yukon forest and Peace parkland (Fig. 2), the two forests most influenced by human activity. It is unlikely that the Peace parklands ever had a high population of marten, as it was ecologically unsuitable even when first entered by whites. Since then agriculture, fire, and logging have further altered the environment.

Of the better areas, Nelson forest has the highest yield with 12.9 square miles per pelt per annum, and Stikine forest the lowest with 80.3 square miles per pelt.

In this species, as with the wolverine, production east of the Rockies decreases in direct relation to distance from the mountains. Calculations of yield in four regions progressively removed from the mountains are 16, 16, 45, and 124 square miles per pelt. No habitat factor of probable significance included in this study appears to follow a similar pattern, and no explanation can be offered for this trend in marten population.

Fox. Fox production by forest section falls into two distinct groups (Fig. 2), the low-producing Cordilleran forests with production as low as a pelt per 432.6 square miles, and the high-producing forests on the plains, east of the Rocky Mountains, with production as high as a pelt per 15.7 square miles. Production from the Liard plain is of special interest. Geologically this plain is part of the Cordillera, but it is topographically and vegetationally similar to the Nelson forest to the east with which it is continuous through the low and forested Liard Gap. Despite this similarity Liard plain production is one-tenth that of the Nelson forest.

Throughout most of the mountainous west in Canada the red fox is generally distributed, but never reaches the spectacular abundances periodically experienced in the rest of forested Canada. Low production in the mountains may be due in part to an absence of such periodic abundance.

The influence of mountainous terrain was tested further by calculating production for the four areas on the plains, north of the Peace River and bounded by meridians of longitude. Production was found to be, from west at the foot of the mountains to east next to the Alberta border, 45, 17, 13, and 16.5 square miles required to produce one pelt per year. The foothills area here has relatively poor production.

Especially low fox production from the Stikine, and similarly low production there of several other terrestrial fur species, has been noted in discussing squirrel. This low production does not appear to result from any lack of trapping effort, since wolverine, coyote, and wolf are taken there in relatively high numbers.

Beaver. Beaver is perhaps the North American fur species most susceptible to overtrapping. Its workings are obvious, its wanderings are restricted and somewhat predictable, and it is easy to trap as a result. In the Peace parklands, low beaver production (Fig. 2) appears to be a result of heavy trapping in the past, a factor perhaps made more effective by the region's paucity of lakes. In the Yukon forest where human activity has also been relatively intensive, abundant lakes affording better habitat over larger areas may have partially offset heavy trapping pressures. In the remaining five forests, production appears to depend largely upon drainage characteristics. The well-drained foothills south of the Peace and the young drainage systems of the Stikine forest provide less habitat than do the well-watered and poorly drained areas in the Liard, Nelson, and North Peace forests. The Nelson forest especially has poor drainage, which is reflected in high production, one pelt being produced from each 6 square miles.

The influence of drainage on the forested plains was tested further. In four successive areas at progressively greater distances from the mountains (as calculated for wolverine and others), production from west to east was 19, 9, 8, and 8 square miles necessary to produce one pelt per year. The well-developed and rapid drainage of the foothills provided poor beaver habitat.

Fisher. This species is absent from the Yukon and Stikine plateaux, although it occurs on the coast to the west (Anderson, 1946), on the Skeena drainage to the south (Stanwell-Fletcher and Stanwell-Fletcher, 1943), and on the Liard plain to the east. Fisher do not occur at high elevations or high latitudes; indeed, in northern British Columbia the species is at the northern edge of its range. Rand (1945) had no records for Yukon Territory adiacent to British Columbia on the north. The forests in order of fisher abundance are South Peace 175 square miles per pelt, Liard plain 260 square miles per pelt, Peace parklands 330 square miles, North Peace 450 square miles, and Nelson forest 664 square miles per pelt (Fig. 2). The last, despite Quick's (1953) designation of it as an area of fisher abundance, is the least productive of the five eastern forests. The maximum annual yield of fisher, as estimated on six trap lines of high productivity over periods of from 14 to 20 years, is one per 138 square miles.

On the forested plains east of the Rocky Mountains there is a declining trend in yield eastward. The four zones compared yielded 395 square miles per pelt in the foothills and 325, 1,033, and 1,890 square miles per pelt in order eastward away from mountain influence. These findings support observations made elsewhere that fisher favour areas of relatively dry, well-drained, semi-open mixed forest. These conditions predominate in the areas of greatest fisher abundance in the boreal forest.

The fisher, usually considered a rare and intolerant species, has maintained itself in the Peace parkland, while mink, lynx, marten, beaver, and otter seem severely depleted. This may result from especially suitable habitat or from great mobility that leads to continued invasion from adjacent regions of lesser exploitation.

Mink. Mink production (Fig. 2) shows no regular trends. There is low yield in the Peace parklands and like most other fine-fur species it appears to have been reduced by trapping in that area. A clue to its general ecological requirements is provided by its production on the forested plains with progressive distance from the mountains (as calculated for wolverine). These are, from west to east, 118, 77, 45, and 46 square miles per pelt. Poorer drainage with abundant lakes and more sluggish rivers at some distance from the mountains appear to favour this species.

Continued high production in the heavily trapped Yukon forest may be a result of superior habitat resulting from many lakes. The same reasoning has been applied in the case of beaver. In the Stikine forest, 69 per cent of the production has come from a small area with numerous lakes, in a region that elsewhere has few lakes and good drainage.

Lynx. Lynx production (Fig. 2) suggests low populations in the Peace parklands, as noted for most fine-fur species, and low numbers in the Stikine forest. This last is true also of red squirrel, fox, and marten. Poor production is evident also in the restricted and heavily trapped Yukon forests, and in forests adjacent to the heavily trapped Peace parklands. The poorly drained Liard and Nelson forests are highest producers (34.5 and 24.8 square miles respectively to produce one pelt).

Production figures on the Plains, from west to east (as calculated for wolverine) show 58, 44, 38, and 53 square miles necessary to produce a pelt and thus indicate a fairly uniform distribution.

We have no explanation to offer for the low production of lynx and several other forest mammals in the Stikine forest. There are few biological data from these northwestern plateaux, and what few are known suggest that these areas are ecologically unique. Forests follow narrow valleys through extensive tablelands that are dry and cold. Bunch grasses cover large areas, and snow depths are relatively shallow. This is the Cassiar country of big-game hunting fame, where a large form of caribou (*Rangifer arcticus*) occurs and thin-horned mountain sheep (*Ovis dalli*) may be found in some abundance. Apparently those forests that do occur do not provide adequate habitat for a number of species typical of the boreal forest elsewhere.

Coarse-fur Species

It was pointed out earlier that, with respect to squirrel, weasel, muskrat, coyote, and wolf on the areas in and west of the Rocky Mountains, there may be poor corre-

lation between yields and the populations available. However, on forest areas 1, 5, 6, and 7, catch probably does represent population. Here maximum yields are: weasel 1.4 square miles per pelt, muskrat 2.0 square miles per pelt, coyote 11.6 square miles per pelt, while squirrel production reached one per 0.1 square miles. The highest wolf yield has been one animal per 92 square miles.

Further details are presented graphically in Fig. 2.

Comparison of Maximum Yields

Even though the relationship between harvest and population remains unknown, it can be safely concluded that the maximum yields from the best area over several years probably correspond rather closely to the mean annual crop that could be removed. Comparison of maximum yields for each species provides an indication of relative densities reached.

To facilitate this comparison and also to permit comparison with figures presented by Peterson and Crichton (1949) for the Chapleau forest of Ontario, we have prepared Table 1. This shows the production of fur from part of the Chapleau forest in square miles per pelt averaged over a six-year period. It also gives yield figures for the boreal forest of British Columbia. The latter are not strictly comparable to the Ontario data for they are not mean figures for the entire region, which would be relatively meaningless. For each species the highest yield figure for any of the seven forest subregions is used. Thus the beaver figure is from Nelson forest, the muskrat from Peace parklands, etc.

Comparing the maximum yield figures as derived from the boreal forest of British Columbia, it is evident that the otter is the rarest fur bearer, followed by wolverine and fisher. Wolf and squirrel do not appear in Table 1. Neither involves a yield produced through the full 20 years. Best production for wolf is 92 square miles per pelt (19-year average) and for squirrel 0.1 square mile per pelt (13-year average).

Comparisons between two such widely separated areas as Ontario and British Columbia must be undertaken with caution. Only as production figures are the values in Table 1 directly comparable. From this aspect it is evident that per square mile the country south of the Chapleau Game Preserve produced more otter, fisher, mink, fox, beaver, and muskrat. Since figures for northern British Columbia are in each case from the best-producing areas, the Chapleau region is by comparison an area of considerably higher fur production.

Table 1 emphasizes the lower production of fine fur in two widely separated areas. Although there may be exceptions depending upon the area concerned, fine-fur species appear to give low fur production primarily because of inherently low population density. Also, as a group, they appear to be particularly sensitive to habitat modification by man. These two characteristics combine to make fine fur a resource that is especially liable to deterioration when under inadequate management.

TABLE 1. — FUR YIELDS IN SQUARE MILES PER PELT IN NORTHERN BRITISH COLUMBIA AND ONTARIO

	Boreal Forest of B.C. Average of 20 Yrs.	Chapleau District, Ontario Average of 6 Yrs.
Otter	1,298	50
Wolverine	236	—
Fisher	159	104
Lynx	25	317
Mink	19	7
Fox	16	13
Marten	13	35
Coyote	12	—
Beaver	6	4
Muskrat	2	1
Weasel	1	9

In much of the boreal forest, fur is a major resource with human populations dependent upon it for a large part of their livelihood. The boreal forest is also a major producer of fine fur for the fur industry. If this fur resource is to maintain its importance in supporting human populations, fur management should concentrate its efforts upon fine fur, for coarse-fur production can be maintained, and even increased, under heavy exploitation accompanied by little organized management effort.

SUMMARY

The boreal forest in northern British Columbia is divisible into seven subregions differing in topography, vegetation, the extent of burns, proximity to alpine or grassland conditions, the abundance of man and his works, and other factors. Data from annual reports of white trappers enable calculation of the average annual production of fur, by species, for these seven subregions. The years involved are from 1929 to 1948 inclusive. The production of 12 fur-bearing species is shown graphically, and figures for another (otter) are given in the text. For most species, it is possible to offer explanations for differences in production shown in the graphs.

It is also noted that the fur bearers fall into two groups, those with fine fur, and those with coarse fur. The factors influencing the production of these two groups are quite different. Fine fur tends to be taken in proportion to the size of the fur-bearer population concerned, while coarse-fur production is the result of several factors influencing the intensity of effort that trappers direct toward harvesting the species with coarse fur.

A major conclusion is that careful management is less important for coarse-furred species than it is for species with fine fur. The latter are usually present in lower densities, and have proven more vulnerable to reduction by human influences.

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SPRING AGING METHODS FOR RUFFED GROUSE COCKS[1]

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Each spring from 1954 through 1956, personnel from the Forest Game Research Project of the Wisconsin Conservation Department have mirror-trapped 100 to 160 breeding male ruffed grouse (*Bonasa umbellus*) (for techniques, *see* Dorney and Mattison, 1956). Age breakdowns of these spring samples into juveniles (cocks hatched the previous year) and adults (hatched two or more years before) are vital information for the following purposes: (1) Adult turnover can be computed from these spring age ratios for a population with a known status. (2) A comparison of fall and spring age ratios will indicate differential age losses through the winter months as well as differential hunting vulnerability. Normally the juvenile sex ratio is even, while the adult sex ratio may be distorted to as many as 150 males to 100 females. Any disproportionate winter loss of juveniles, therefore, would have a depressing effect on the following year's productivity.

Fall-shot ruffed grouse are generally aged by means of the contour of the 9th and 10th primaries (outer two), the bursa (Bump, *et al.*, 1947; Petrides, 1942), and the sheathing or scale at the base of primaries 8 to 10 (Hale, *et al.*, 1954). However, these fall techniques are not always applicable for April, May, and June birds, since the bursa has regressed considerably by spring, and the tips of the 9th and 10th primaries may be either wet or broken in the trap. Sheathing is a better spring age character, but may be obscure on some cocks. Accurate spring aging is, therefore, quite difficult for many birds. More objective criteria are clearly needed. This paper describes new techniques developed for accurate spring age classification.

[1] A contribution from P-R Project W-79-R-1 of the Wisconsin Conservation Department. The authors wish to express their appreciation to Cyril Kabat and Ruth L. Hine for critically reviewing the manuscript. Russell Mattison assisted in collecting the data from the field.

Methods

Our approach is based on the fact that juvenile grouse retain their outer two primaries until the following summer, and these primaries have smaller shafts than those in adult primaries (Petrides, *op. cit.*). Also, juvenile males in general have shorter rectrices than adults (*ibid.*; Hale, *op. cit.*).

Our first step was to take the dried wings and one central tail feather from fall-shot cocks and divide them into 559 juveniles and 249 adults on the basis of primary contour and sheathing. All the specimens came from Rusk, Sawyer, and Dunn counties, the counties in which we were mirror-trapping in Wisconsin.

The 9th primary was plucked from the dried wings and the diameter of the shaft measured with a micrometer to the nearest thousandth of an inch. This measurement was made at the point on the shaft where the larger proximal barbs begin, and at right angles to the barbs. We worked with the 9th primary rather than the 10th, since on live birds the shaft of this feather is sufficiently exposed so that calipers or a gauge can be slipped over the shaft in the field without having to pluck the primary.

On the dried central tail feather, two measurements were made: total length and the shaft diameter at the point where the first barbs emerge and at right angles to the barbs. The shaft diameter was taken to the nearest one-thousandth of an inch with a micrometer, and the length to the nearest millimeter.

As a result of the above measurements on the fall-shot sample, we devised the following method for aging spring-trapped cocks in the field. First, a metal gauge with a preset gap was developed for measuring the diameter of the 9th-primary shaft. Fig. 1 shows a live-trapped bird being aged with this wing gauge. The gauge is placed over the 9th-primary shaft from the under side of the wing. If the shaft is wider than the gauge, the bird is considered adult; if smaller, juvenile. In addition, one central tail

FIG. 1. Wing gauge being slipped over the 9th primary to measure the shaft and thereby determine the bird's age.

feather is then plucked from all trapped birds. After allowing two months to dry, the tail feathers are measured in the office and age determined. In addition, observations are made on the bursa, wing contour if possible, and sheathing on all live birds. The sheathing can be seen by gently pulling the coverts to one side, exposing the bases of the primary shafts.

FINDINGS

Figs. 2, 3, and 4 show frequency distributions for shaft diameters of the 9th-primary and central tail feather, and for the length of the central tail feather. These data came from the sample of dried wings and tails from known-age birds shot in the fall. On the average, juveniles have narrower 9th-primary shafts and central tail feather shafts and have shorter tail feathers than adults. Considerable overlap occurs on all these measurements, however. To reduce this overlap error, two separation points are used for the tail measurements (Figs. 3 and 4). Any tail measurement falling into the unknown group between the separation points is not used for age determination. This unknown-age group is helpful in reducing the error in tail measurement that would otherwise occur, thereby making age determination for individual birds more accurate. However, between 25 and 47 per cent of the sample is thereby eliminated. Only one separation point is used for the 9th-primary measurement (Fig. 2) since two gaps would be needed in the wing gauge—a minimum and maximum, thereby unnecessarily complicating field operations. All the separation points in Figs. 2 to 4 were determined by inspection of the data.

As these three figures show, these primary and tail measurements are strongly correlated with age. However, they are not closely related to each other, and have a strong tendency to be independent. This independence is important, since it means that, if a juvenile bird has an "adult" 9th-primary shaft, the probability is that it would have a juvenile tail shaft and/or length, thus canceling the wing error.

As an additional help in aging spring-trapped cocks, the bursa, contour of the 9th and 10th primaries, and sheathing at the

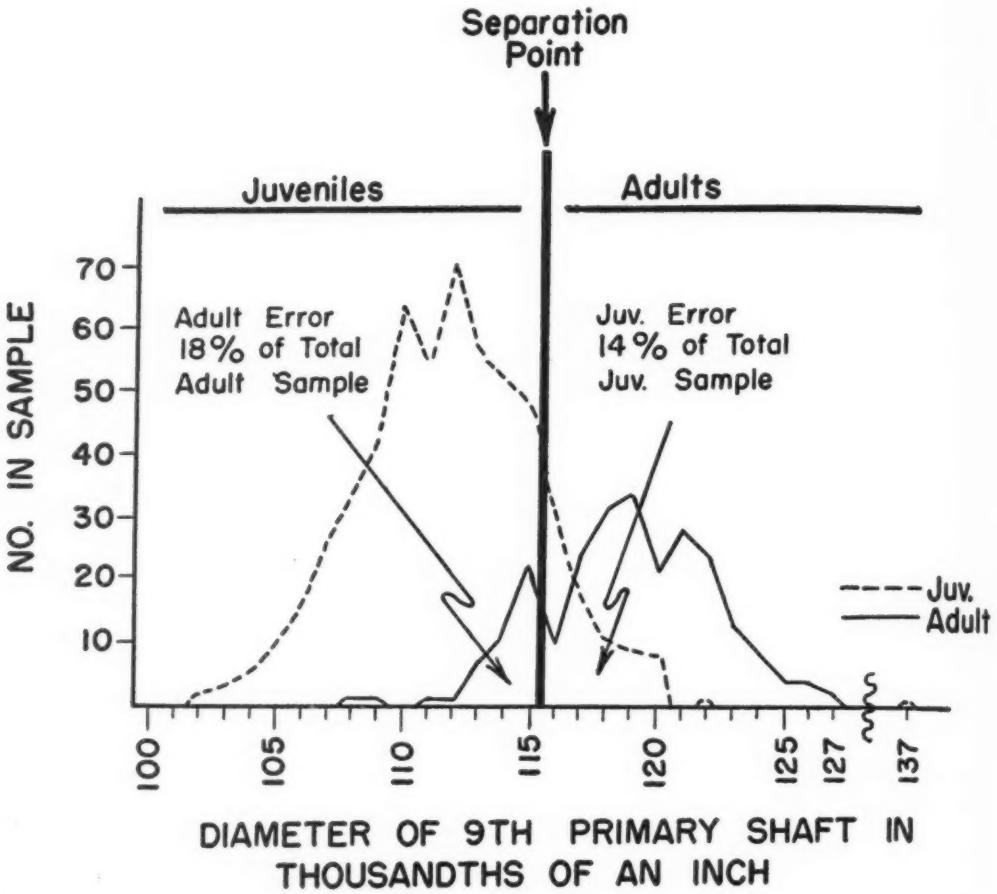

FIG. 2. Frequency distribution of the diameter of the 9th-primary shaft for 559 juvenile and 248 adult primary-aged male ruffed grouse shot in fall. A single separation point is used to segregate specimens into juvenile and adult with indicated percentage of error.

TABLE 1. — CRITERIA USED FOR AGING COCKS LIVE-TRAPPED IN SPRING

Criterion	Juvenile	Adult	Unknown
Shaft diameter 9th primary	117/1000* or less	117/1000 or more	none
Shaft diameter central tail feather (dried specimens)	87/1000 or less	92/1000 or more	88-91/1000
Length central tail feather	159 mm. or less	170 mm. or more	160-169 mm.
Bursa	not used	closed	1 mm. plus
Wing contour	pointed	rounded	none
Sheathing at base of primaries 8 to 10	present on 8th only	present on 8th, 9th, 10th	none

*Thousandths of an inch

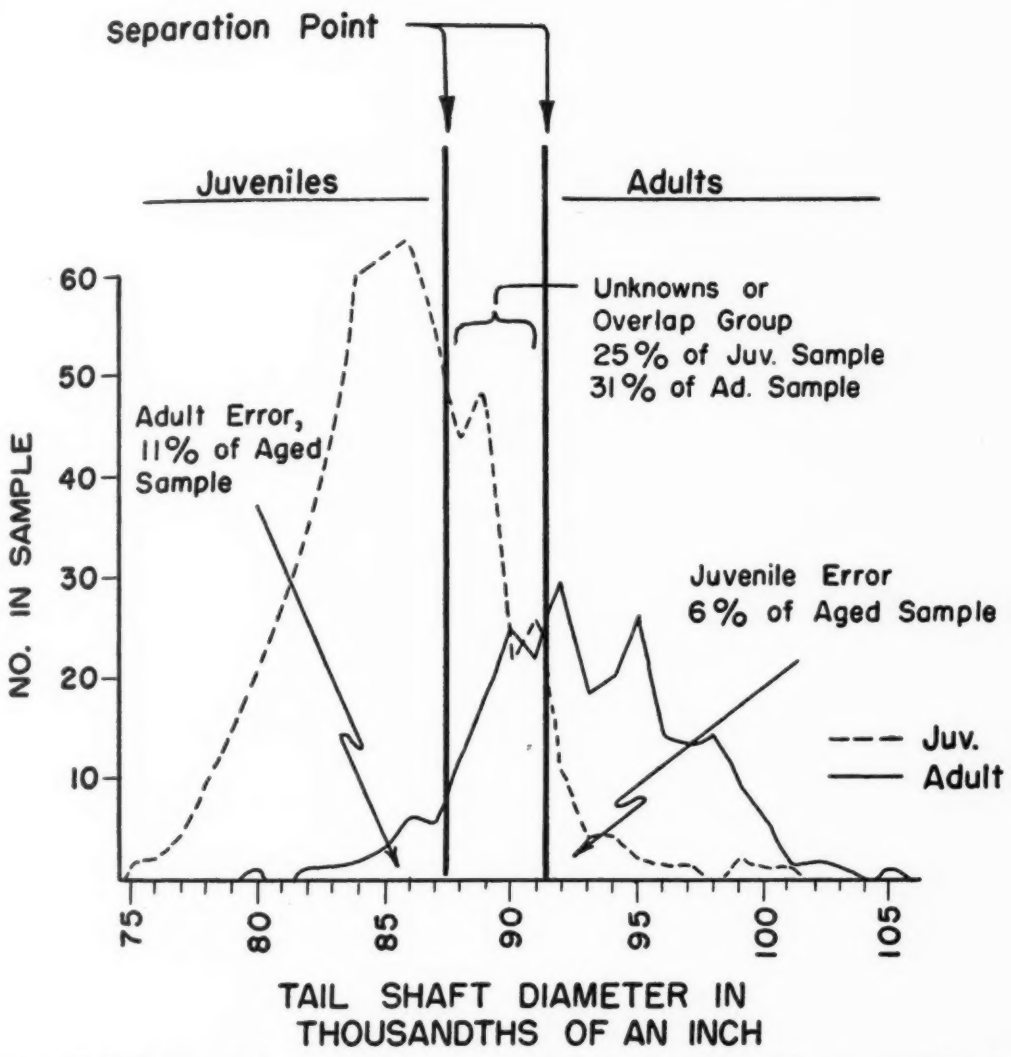

FIG. 3. Shaft diameter of the central tail feather of 249 adult and 559 juvenile primary-aged male ruffed grouse, showing separation points used to classify specimens into juvenile, adult, and an unknown age group.

base of primaries 8 to 10 are also recorded, if possible. Thus, as many as six aging criteria are used for each bird trapped in the spring. In Table 1 a summation of these six age criteria is shown. The separation points for the tail measurements in Table 1 are the same as indicated in Figs. 3 and 4. The wing-gauge gap in Table 1 is indicated as 117 one-thousandths of an inch rather than the 115 one-thousandths indicated in Fig. 2 for dried wings, since we found that the 9th-primary shaft will shrink about 2 one-thousandths of an inch after drying. The bursa has proved to be a useful criterion for adults only, since it is closed in about one-half of the adults. Some residual depth is still present in spring in the remainder of the adults and all juveniles.

Table 2 shows actual data on several spring-trapped males. As shown by the examples in this table, the final classified age of a bird can be—juvenile, adult, or unknown. For instance, birds with band numbers 627 and 629 are both classified as

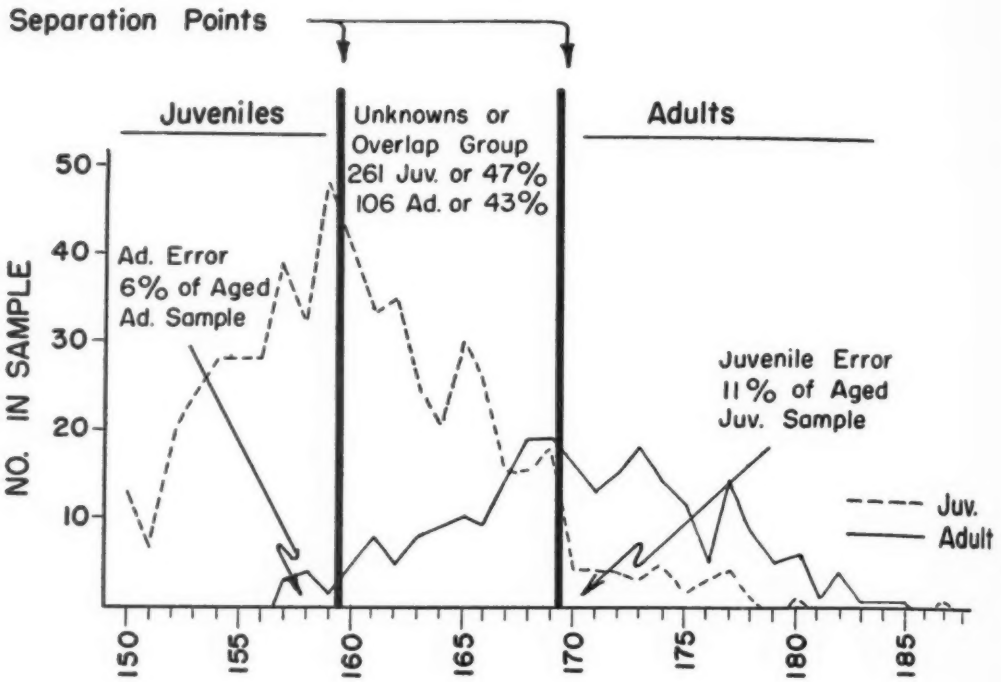

FIG. 4. Distribution of tail length for 249 adult and 559 juvenile primary-aged male ruffed grouse shot in fall. Two separation points segregate the sample into juvenile, adult, and an unknown group.

juveniles, although 629 has one measurement (tail length) that is adult. This adult character is ignored, since the other two criteria indicate this bird to be a juvenile. Number 153, according to the wing gauge, is a juvenile; however, three other criteria indicate it is an adult. Hence, the bird is classified as an adult and the wing-gauge measurement ignored. Number 603 is a bird of unknown age, since two measurements indicate adult and two indicate juvenile. In actual practice, less than five per cent of the cocks will fall into the unknown-age category. Any single measurement falling into the overlap range is ignored and shown in Table 2 with a question mark.

The final proof of any method is how it actually works on a sample of known-age birds. Fortunately, in the spring of 1956 we trapped 39 adults previously banded in the springs of 1953 to 1955, and also retrapped 16 cocks banded as juveniles in the fall of 1955. Table 3 shows how the ages of these 55 birds were classified in spring, using the combination of all our age criteria. The actual age ratio (16:39) is almost identical to the computed age ratio (15:38) using the six age criteria. This shows a very small margin of error.

DISCUSSION

The use of six aging criteria has an additional advantage. When untrained personnel are hired for trapping, the chance for error is considerably decreased by using more than one age character. Since mirror-trapping of large samples requires additional man power, this is an important point.

One variable that needed to be standardized was the shrinkage in all feather shafts after drying. Since all the original measurements were taken from dried wings and tails, we measured the average shrinkage rate from freshly plucked primaries and adjusted the gap in the wing gauge, as mentioned

TABLE 2. — EXAMPLES OF AGE DATA TAKEN ON INDIVIDUAL SPRING-BANDED COCKS

Band No.	Date Trapped	Wing Gauge	Tail Shaft Diameter	Tail Length	Bursa	Wing Contour	Wing Sheathing	Final Age
627	4/19/56	minus* (J)**	80 (J)	150 (J)	4 mm. (?)**	pointed (J)	not taken	juvenile
629	4/21/56	minus (J)	91 (?)	172 (A)**	8 mm. (?)	pointed (J)	not taken	juvenile
659	5/6/56	plus* (A)	98 (A)	173 (A)	2 mm. (?)	rounded (A)	not taken	adult
153	5/5/56	minus (J)	91 (?)	174 (A)	closed (A)	rounded (A)	not taken	adult
603	5/3/56	minus (J)	92 (A)	161 (?)	1 mm. (?)	rounded (A)	8th only (J)	unknown

*Minus, less than 117/1000; plus, more than 117/1000
**(J) juvenile, (A) adult, (?) unknown

previously. From a sample of 49 fresh primaries we found an average shrinkage of 2 one-thousandths of an inch after five months of drying. We then opened our wing gauges by this amount to correct for this differential between fresh and dried shafts. Table 1 shows the gap size for live birds, 117 one-thousandths of an inch. All field data in Tables 2 and 3 were obtained with the wing gauge set at 117 one-thousandths. Tail-shaft shrinkage was ignored, since the plucked feathers were dried for two months before they were measured. Thus, the separation points for tail feathers in Table 1 are for dried feathers.

Due to geographic variation in the size of ruffed grouse (Howe, 1951), the separation points used in Table 1 would probably have to be modified if used elsewhere.

Some comment should be made about the persistence of the sheathing at the base of the three outer primaries in spring. Although sheathing is not as distinct in spring as in fall, any field worker who has aged ruffed grouse in fall with this technique would have little trouble distinguishing juvenile from adult sheathing in spring. Often in the course of our field work we did not record sheathing when we felt the age of the bird had been well established with other criteria. In Table 2 the sheathing was not recorded on many birds for this reason.

No mention has been made of the hen ruffed grouse. Unfortunately, no method for trapping large samples of hens in spring exists, and at the present time we have found no need for spring aging techniques for this sex. We did measure the tails of a small sample of hens shot in fall and found no age differences. The 9th-primary shafts, however, did show an expected difference between juvenile and adult hens. The females would have a different separation point, however, from that shown for males in Fig. 2. Thus, primary contour, sheathing, 9th-primary shaft size, and possibly the bursa would all be valuable age criteria for hens in spring.

It is quite possible that our general method of multiple age criteria could also have application to other birds and mammals.

TABLE 3. — CLASSIFIED AGES OF RUFFED GROUSE OF PREVIOUSLY KNOWN AGE TRAPPED IN THE SPRING

	Classified Ages			
	Juvenile	Adult	Unknown	Totals
Known to be adults	1	37	1	39
Known to be juveniles	14	1	1	16
Totals	15	38	2	55

SUMMARY

An aging method developed for ruffed grouse cocks trapped in spring was based on the use of six age criteria—diameter of the 9th-primary shaft, diameter of the cen-

tral tail-feather shaft, central tail-feather length, bursa, primary contour, and primary-feather sheathing. Spring cocks were classified as juveniles or adults with a high degree of accuracy.

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AN ANALYSIS OF VARIANCE APPLICABLE TO TRANSECT POPULATION DATA[1]

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Studies of deer (*Odocoileus virginianus*) populations often involve a comparison of estimated population numbers, indices, and other characteristics. Although it is sometimes desirable to obtain total population estimates, relative population counts frequently serve the purpose of the investigator. Such counts may be used in determining and locating the better hunting areas in a state, and they may be useful in studying the habitat in relation to population density with the ultimate aim of manipulating the habitat or deer herd. Population densities of deer have been studied by various methods, e.g., road counts, trail counts, strip censuses, drive censuses, aerial counts, pellet counts, and studies of deer bagged by hunters.

This paper is concerned with the collection, analysis, and interpretation of trail-count deer data from Bath County, Virginia in 1953–54. An attempt is made to utilize statistical procedures in the analysis and show that these procedures resulted in biologically acceptable conclusions. Computational procedures are omitted, as such information is available in the cited references and in statistical texts.

The Bath County deer-herd investigation was initiated at the request of the Virginia Commission of Game and Inland Fisheries to determine whether or not the deer herd was out of balance with its environment. The collection of trail-count data was only a small facet of the entire project reported upon by Muncy (1954).

Bath County is located in west-central Virginia in the Allegheny Mountains. It is characterized by a relatively high native deer population. In certain areas in the county the 1951 population was reduced in the summer of 1951 by a "die-off" resulting from unknown causes (Muncy, *op. cit.*). Seventy-two per cent of the county is forested and a large portion of the county (46 per cent) is within the George Washington National Forest.

Deer hunting is fairly intensive, as indicated by the sales of deer and bear-damage stamps required of all sportsmen hunting big game in the county. The numbers sold were 4,770, 5,891, and 5,310 for the years 1951, 1952, and 1953, respectively. The legal buck kill during these years was 465, 709, and 689. A legal buck is a buck recorded at a checking station as prescribed by law.

[1] Release No. 57-2, Virginia Cooperative Wildlife Research Unit.

METHODS

Sampling.—Since deer-population differences apparently existed in the county, the county was subdivided into four areas on the basis of postulated deer population and habitat differences. It should be realized that the sections were distinct entities only as a result of delineation by the writers. Three walking observation lines were established in each of the four areas to obtain information on comparative population numbers. All lines were located along unused logging roads and existing trails, preferably those that crossed the different drainages of the areas. Existing lines were utilized to reduce observer disturbance to a minimum and allow maximum mental concentration by the observer. The selection of lines by such a procedure is open to criticism because bias can easily be introduced into the sample. A random selection of possible lines would have required considerable clearing, consequently resulting in a modification of habitat and disturbance of the population, both being undesirable. A procedure more acceptable than the one followed in this study would be a random selection of existing line segments from a list of all possible existing line segments in each study area. An additional disadvantage of using roads or trails is that they may not transect "representative" habitat of the entire study area, e.g., the amount of edge would be in excess. As a large percentage of deer hunters hunt along such trails and roads, it is felt by the writers that populations of primary interest may be along these trails and roads; thus, sampling existing roads and trails would be a satisfactory procedure. Some of the selected lines were entirely covered by a forest canopy while others passed through a considerable amount of cleared and logged-over areas. An attempt was made to select comparable lines, again a procedure open to criticism as the question of bias arises; however, this may be a practical procedure where the number of possible lines is limited.

In essence our assumptions are similar to those of Kozicky, Hendrickson, Homeyer, and Speaker (1952): (1) the sampling units were selected at "random" within the four areas, i.e., our sample is equivalent to a random sample; and (2) there is a reasonable correlation between the number of deer observed and the total number of deer in the areas. Assumption (*1*) is a critical assumption and can only be eliminated by an actual random-sampling procedure.

The lines were of a uniform length of 2,200 yards. An attempt was made to standardize direction of travel and time of observing and to have comparable weather conditions during the observation periods. Monthly observations on the same line were always obtained by walking in the same direction approximately one-half hour before sunset on days with no rain falling within 2½ hours of this time. The time required to walk lines varied from 40 to 60 minutes. All 12 lines were walked once a month for a period of seven months, August, 1953 through February, 1954, with the observations being completed as near the first of the month as possible. The order of running the 12 lines each month was determined from a table of random numbers.

In addition to the above data (Table 1), a limited number of pellet lines was established, one in each of three areas and two in the remaining area. One automobile road count was conducted in each of two study areas. As these data are scanty and of minor importance to the theme of this manuscript, details concerning their collection and interpretation are omitted in this paper; however, this information has been reported by Muncy (*op. cit.*).

Analysis.—The statistical analysis consists of an analysis of variance for a partially hierarchal model as described by Harter and Lum (1955). The model states that the number of observed deer (y_{ijk}) on the k^{th} line ($k = 1, 2, 3$) during the i^{th} month ($i = 1, 2, \ldots 7$) in the j^{th} region ($j = 1, 2, \ldots 4$) is expressable as a linear function of the grand mean (μ), fixed month effect (α_i), fixed area effect (β_j), random line effect (c_{jk}) and the month × area interaction ($\alpha\beta_{ij}$). It was assumed that the residual errors (e_{ijk}) were normally and independently distributed around zero with constant variance. The model is written as

$$y_{ijk} = \mu + \alpha_i + \beta_j + c_{jk} + \alpha\beta_{ij} + e_{ijk}.$$

This model or a model with modifications in the kinds of effects is not restricted to data of the type collected in this study but is applicable to other types of "census" data.

TABLE 1. — NUMBER OF DEER OBSERVED ON WALKING OBSERVATION LINES IN 4 AREAS DURING 7 MONTHS IN BATH COUNTY, VIRGINIA, 1953–1954

Area	I			II			III			IV			Monthly Average
Line	1	2	3	4	5	6	7	8	9	10	11	12	
Month													
August	5	6	7	2	0	4	1	0	1	2	0	0	2.33
September	14	9	3	0	0	11	0	1	0	1	1	0	3.33
October	7	4	3	3	2	15	0	0	0	0	0	0	2.83
November	6	2	9	0	6	1	0	0	0	0	0	0	2.00
December	7	1	3	0	0	0	0	0	0	0	1	0	1.00
January	5	8	1	0	1	0	0	0	0	0	0	0	1.25
February	3	2	8	0	0	0	0	0	0	0	1	0	1.17
Area average		5.38			2.14			0.14			0.28		

Hartley, Homeyer, and Kozicky (1955) have applied a transformation to the pheasant census data reported upon by Kozicky, *et al.* (*op. cit.*) to satisfy the assumption of homogeneity of the error variance. They state, "Theoretically, if x stands for the number of pheasants [deer] observed per mile [2,200 yards] and there is a linear relation between the standard deviation σ_x and the mean value μ_x of the form $\sigma_x = a + b\mu_x$, the transformation to be used is given by $y = \log (a + bx) = \log b\,(x + a/b) = \log (x + a/b) + \log b$ in which the constant $\log b$ can, of course, be omitted." In an attempt to see if the standard deviation varied in proportion to the mean deer count, a regression of the standard deviation of counts within a month on the average monthly deer count was computed (Fig. 1). It is apparent that only one point deviates from a linear relationship of the form mentioned by Hartley, *et al.* (*op. cit.*). The regression coefficient ($b = 1.1398$) of the standard deviation on the mean number of deer per month is statistically significant at the 1 per cent level of significance. The choice of a/b suggested by the fitted regression is 0.8; consequently, the variate transformation $y = \log (x + 0.8)$ was used in the analysis.

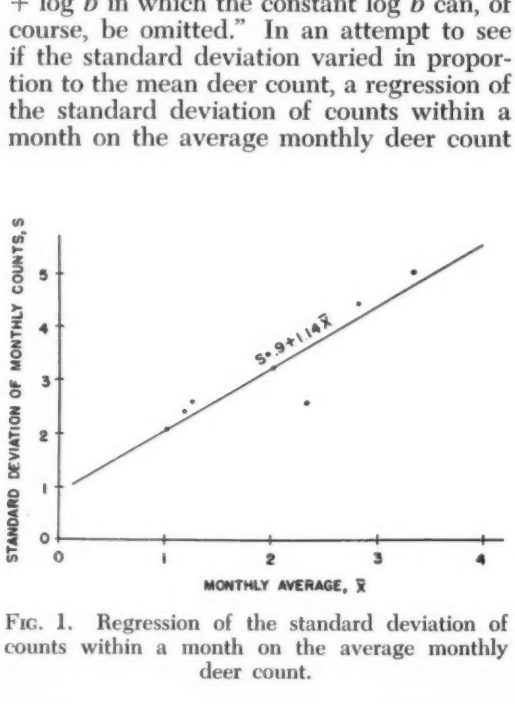

FIG. 1. Regression of the standard deviation of counts within a month on the average monthly deer count.

Following the analysis of variance, a comparison of more than two means was accomplished by the use of a multiple-range test described by Duncan (1955).

RESULTS

Main effects.—The analysis of variance showed a statistically significant difference (5 per cent level of significance) between the averages for months (Table 2). The primary source of variation can be attributed to a before (Aug., Sept., Oct.) and after (Dec., Jan., Feb.) hunting-season effect. There was a highly significant difference (1 per cent level of significance) between the average number observed before (2.83 deer) and after (1.14 deer) the hunting season.

Such a result is biologically acceptable, since a reduction of the deer herd on the lines resulting from hunter removal and population movements occurred during the legal hunting season from November 16 through 22, 1953; however, one should be wary of the conclusion that this indicates a 50 per cent reduction in the population.

TABLE 2. — ANALYSIS OF VARIANCE OF DEER OBSERVATION DATA (TRANSFORMED) FROM 3 LINES IN EACH OF 4 POPULATION AREAS OF BATH COUNTY, VIRGINIA, OVER A PERIOD OF 7 MONTHS

Source of Variation	Degrees of Freedom	Mean Square	*F*-ratio
Months	6	0.1490	2.4*
Aug., Sept., Oct., vs. Dec., Jan., Feb.	1	0.8837	14.1**
Remainder	5	0.0020	0
Areas	3	2.6636	32.1**
Lines within areas	8	0.0830	No test
Month × area	18	0.0722	1.2
Aug., Sept., Oct., vs. Dec., Jan., Feb.	3	0.1877	3.0*
Remainder	15	0.0491	0.8
Remainder	48	0.0627	
Total	83		

* Significant at the 5 per cent level
** Significant at the 1 per cent level

Since hunters scouted the woods and disturbed deer prior to the legal season, observations on the lines during the forepart of November were not utilized in this comparison. It is conceivable that the difference between the average number observed before and after the hunting season could be used as an index to population kill during any one season *provided that* deer activity related to time can be accounted for. Regardless of this time effect throughout a season, one should be in a position to evaluate differential kill during various legal seasons, *provided of course the time effect from season to season is relatively constant or can be accounted for.*

A comparison of months on an individual basis, using a multiple-range test (Duncan, *op. cit.*), disclosed a statistically significant difference between the average counts in December and August, and December and September.

A comparison of area averages showed a highly significant difference (1 per cent level of significance) between areas (Tables 1 and 2). There was a significant difference (5 per cent level of significance) between individuals of all pairs of averages except between areas III and IV. This is assuring, since prior to conducting this study the junior author believed that area I had the highest deer population and area II was the next highest while areas III and IV were considered to have a low population. It should be realized that the areas were established by the junior author on the basis of observations prior to establishing "census" lines; thus, if his opinions were based primarily on observations on the selected lines rather than over the entire area, the statistical findings were to be expected. This study therefore indicates that a capable field biologist familiar with an area is in a position to make reliable statements on relative population levels on the area of such a nature as to be of value to hunters and game managers; however, one should recall that the population differences in this study were fairly large.

It is interesting to note that pellet-line data show the same general relationship, i.e., the areas could be ranked in decreasing magnitude of pellet groups per acre as follows: I, II, III, and IV. Automobile road counts in areas I and III resulted in more deer being observed from the road in area I than in area III.

As a result of the method of selection of observation lines, it is risky to make other than the most general comments on the relative density of deer in the various regions. Since it is possible to make a random selection of pellet lines in an area, the writers believe that the pellet-count method of obtaining deer-population data offers the greatest possibility of arriving at more specific and reliable conclusions through statistical techniques. We recommend that detailed studies be conducted on the characteristics of pellet-count data, e.g., on the

value of stratification by cover types and an evaluation of seasonal effects.

Our data contain a limited indication that automobile roadside counts may be a useful management tool due to the flexibility they allow in utilizing nontechnical personnel in making counts.

Interactions.—The month × area interaction was not significantly different from zero (Table 2). In an attempt to study the assumption of additivity in the model, the month × area interaction sum of squares was reduced to two component parts: (1) area x before and after the hunting season, and (2) remainder. The before and after hunting-season component was statistically significant (Table 2), which implies that the before to after hunting-season effect was not the same in all regions. This indicates that the assumption of additivity was not valid. Undoubtedly this is the result of the very low deer counts before the hunting season in areas III and IV, which could not possibly show a decrease after the hunting season such as occurred in areas I and particularly II (Table 1). Such a result might not be observed where counts of zero, one, or two deer are not common.

ACKNOWLEDGMENTS

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Various persons in the Department of Biostatistics, Johns Hopkins University, advised on the analysis and preparation of the manuscript while the senior author was associated with that Department.

CONCLUSIONS

The statistical analysis presented in this paper appears to be applicable to deer-population studies of the Virginia type, utilizing the walking observation line method of collecting population data, and the model is probably applicable in studies utilizing other methods of obtaining population data. Before utilizing this specific procedure, consideration should be given as to whether or not the objectives of a proposed study justify the effort involved and the precision obtained in this method of collecting deer-population data. It is recommended that the pellet-count method be given first consideration in deer population-density studies, since it is possible and practical to select pellet lines at random. Use of this method eliminates the sampling bias inherent in many other methods. Considerable thought should be given to utilizing a nonrandom sampling procedure in place of a more desirable random sampling procedure, even though the former may appear to be more practical. The results of this Virginia study indicate that wildlife biologists may have the ability to rank by density some deer populations by visual inspection. However, it is often desirable to collect population data by some suitable objective procedure, in order to present data to the public to substantiate reliable opinions.

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SOME VITAL STATISTICS IN A HEAVILY EXPLOITED POPULATION OF CARP

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Although carp control in its various forms has been an important part of the work of many state conservation agencies during the past 30 years, there have been relatively few opportunities to study the effectiveness in operation of the various methods of control. Such an opportunity was made available when the need for carp control became acute in Lake Wingra, Dane County, Wisconsin, in 1953.

Control of the carp (*Cyprinus carpio*) has sometimes been pursued under the assumption that a population can be greatly reduced by seining and that when the catch per unit of effort falls, indicating a state of overfishing, a satisfactory degree of control has been attained. Since carp control operations of this kind are costly, manpower limited and the fish usually sold, a profit and loss rationale often guides the control program, and indeed it is often taken for granted that carp are not a serious problem wherever an economic fishery cannot be maintained. It is sometimes valuable to attempt to describe such a fishery from the standpoint of its usefulness as a device for controlling carp rather than from the standpoint of its economics. The objective of this paper is to provide such a description, using estimates of population size, mortality rate and rate of recruitment computed from data provided by the fishery itself.

Study Area and Methods

Lake Wingra has supported a relatively dense population of carp for at least 25 years, seemingly offering good habitat for this species. The lake (Noland, 1951) has a surface area of approximately 320 acres; it is shallow enough (the mean depth is about 7 feet) so that it does not stratify in summer and so that the water temperatures remain high throughout a 4- or 5-month period. It has hard water and a soft bottom, largely marl. The shape of the basin is regular and offers no important obstacles to the operation of large seines. Numerous species of fish in addition to the carp occur in the lake, many, like the carp, having been introduced.

The lake is close to a center of urban population (it lies within the city of Madison) and is heavily fished for both game and pan species. Efforts have been exerted since 1936 to "control" the carp through periodic exploitation of the population with a seine fishery, ostensibly with the remote objective of exterminating the carp completely, and with the more proximate one of maintaining its numbers at levels continuously so low that its ability to interfere with the sport fishery or to affect the lake adversely in any way would be substantially curtailed. The gear ordinarily used in this fishery has been a net with 3-, 4- and 5-inch meshes (stretch measure) about 15 feet deep and normally long enough to include the entire lake in a single haul, although usually of necessity laid at some distance from shore in places.

Since 1936, nettings consisting of a single haul have been made at irregular intervals, never oftener than twice in a calendar year and averaging, until 1953, about once in 3 years. The single hauls had never permitted estimates to be made of the efficiency of such a unit of effort, it being ordinarily assumed that so large a seine would leave only a negligible fraction of the standing population behind after being drawn once. Beginning in the fall of 1953, nettings consisted of from 2 to 6 replicated hauls, among which various numbers of fish taken from the catches of the earlier hauls were marked by fin clipping and released, to be recaptured in the later ones. A detailed schedule of procedure in each of the nettings follows:

Netting 1, November, 1953: Two hauls were made with a net laid around the entire lake, the first begun on November 12 and completed on November 13, the second begun and completed on November 17. From the

catch of the first haul, 560 fish were reserved, 300 of these were marked by removing the tip of the dorsal lobe of the tail and 260 by removing the distal 2/3 of the anal fin. All of these were released at the center of the lake between the two hauls.

Netting 2, March, 1954: Six hauls were made during a three-week period, two hauls in each week, beginning on March 18. In each of these hauls the net was laid so as to include only part of the lake, its west end (with about 2/3 of the total area) in the first haul of each week, the east end (with the remaining area) in the second. The areas covered by alternate single hauls were essentially nonoverlapping, and no attempt was made to prevent the movement of fish from one end to the other between successive hauls. During the first two of the six hauls, additional tagged fish were released. From the catch of the first haul in the west end, 450 fish were reserved, marked by removing the left pelvic fin and released in the west end. Similarly, 395 fish taken from the catch of the first haul in the east end were marked by removing the right pelvic fin and released in the east end.

Netting 3, October, 1955: Six hauls were made during a two-week period beginning October 19. The first three hauls were made on consecutive days followed by an interval of two days; the fourth haul was made on the sixth day, and the fifth and sixth hauls on the eighth and ninth days. Like those made in 1954, each haul included only part of the lake. Four of the six were made in the west and two in the east end of the lake. During the first two hauls, additional tagged fish were released. Following the first haul, 293 fish were returned to the middle of the lake with the right pectoral fin removed; 200 were similarly marked and returned after the second haul. In addition, all previously marked fish (left from other years) that were taken during the first two hauls were re-marked by removing the left pectoral fin, and released. In hauls later than the second, recaptured fish bearing any of the marks applied in 1955 were once again re-marked by removing the posterior portion of the dorsal fin and again released.

In every instance, the catch of a single haul was enumerated fish by fish, each individual being handled and examined for mutilated fins. The mean lengths and weights of fish in some of the catches (noted below) were determined from samples taken while the catch was being counted.

We should like to acknowledge with thanks the extensive assistance in the seining and other field work received from the Rough Fish Control Section of the Wisconsin Conservation Department, which provided us with the heavy gear and the additional personnel necessary to operate it. Without such help we would have been completely unable to accumulate the data used in this investigation.

Catch statistics for all of the hauls are given in Table 1 and summaries of recaptures of the various kinds of marked fish are given in Tables 2 and 3. At least from spring to fall, there is no consistency in the distribution of catch from one end of the lake to the other (compare 1954 and 1955); the concentration of carp in the west end that appeared in the spring of 1954 may characterize the population in winter or when the water is cold, just as the more uniform distribution found in the fall of 1955 may reflect summer or warm-water conditions. Nothing in addition to these data is available for describing seasonal movements of the carp within the lake.

RECOVERY OF MARKED FISH

All calculations made below of population size, mortality rate and rate of recruitment are founded ultimately upon recovery of marked fish. Such data as are available in this study do not make it possible to prove affirmatively that marked fish of all kinds were subject to the same probabilities of capture in each haul, and that these were the same as the probability of capture for the unmarked fish. However, it is possible to produce several arguments favorable to the inference that no biases affected the recovery of the marked individuals.

The relative frequencies of fish marked in 1953 and 1954 in the catches of the various hauls are given in Table 4. (The term "relative frequency" will be used here to mean the ratio of number of fish belonging to a designated class in the catch of a particular haul or group of hauls to total number of fish of all kinds in the same catch.

TABLE 1.—CATCH STATISTICS FOR CARP SEININGS IN LAKE WINGRA, 1953, 1954 AND 1955

Date	Part of Lake	Number of Fish Caught	Weight of Catch (lbs.)	Average Length (in.)*	Average Weight (lbs.)*
1953					
Nov. 13	all	3,125	15,313	21.3 (78)	4.9 (78)
Nov. 19	all	1,951	8,975	21.2 (57)	4.6 (57)
Total		5,076	24,288	21.26 (135)	4.77 (135)
Removed		4,516	21,543		
1954					
March 18	West	1,711	8,025	21.1 (161)	4.6 (103)
March 19	East	411	1,928		
March 23	West	4,366	19,298	21.1 (310)	4.4 (128)
March 24	East	203	897		
March 29	West	1,686	7,452	20.7 (95)	
March 30	East	43	190		
Total		8,420	37,790	21.06 (566)	4.54 (231)
Removed		7,575	34,390		
1955					
Oct. 19	West	307	1,851	21.9 (40)	6.0 (40)
Oct. 20	East	860	4,119	21.1 (42)	4.7 (42)
Oct. 21	West	173	995		
Oct. 24	East	11	63		
Oct. 26	West	255	1,558	23.0 (80)	6.1 (80)
Oct. 27	West	27	155		
Total		1,633	8,741	22.29 (162)	5.75 (162)
Removed		1,009	5,337		

* Numbers in parentheses are the numbers of fish measured or weighed to obtain these averages.

TABLE 2.—MARKED FISH RECOVERED IN SEINE HAULS OF 1953 AND 1954

Date	Total	1953 Marks			1954 Marks		
		Total	Caudal	Anal	Total	L Pelvic	R Pelvic
1953							
Nov. 17	43 (560)*	43 (560)	28 (300)	15 (260)	——	——	——
1954							
Mar. 18	69 (404)	69 (404)	41 (212)	28 (191)	——	——	——
Mar. 19	29 (785)	25 (335)	10 (171)	15 (163)	4 (450)	4 (450)	——
Mar. 23	411 (1,151)	119 (310)	55 (161)	64 (148)	292 (841)	166 (446)	126 (395)
Mar. 24	23 (740)	7 (191)	3 (106)	4 (84)	16 (549)	8 (280)	8 (269)
Mar. 29	172 (717)	39 (184)	23 (103)	16 (80)	133 (533)	65 (272)	68 (261)
Mar. 30	4 (545)	0 (145)	0 (80)	0 (64)	4 (400)	4 (207)	0 (193)

* Numbers in parentheses are numbers of marked fish of various kinds available to be caught at the time each haul was made. In 1954, the numbers of the 1953-marked fish available have been corrected for estimated winter mortality of 0.219.

The term "exploitation rate" will be used to mean the ratio of number of fish belonging to a designated class in the catch of a particular haul or group of hauls to total number of fish belonging to the same class available in the lake immediately before the haul or groups of hauls.) There are no perceptible trends in any of the columns of this table, i.e.,

TABLE 3.—MARKED FISH RECOVERED IN SEINE HAULS OF 1955

Date	Right Pectoral 1955*	Right Pectoral + Dorsal 1955	Left Pelvic 1954	Right Pelvic 1954	Right or Left Pelvic + Left Pectoral 1955	Right or Left Pelvic + Left Pectoral + Dorsal 1955	Caudal or Anal 1953	Caudal or Anal + Left Pectoral 1955
Oct. 19			5 (84)**	7 (80)			2 (60)	
Oct. 20	18 (293)		15 (79)	25 (73)	2 (12)		10 (58)	0 (2)
Oct. 21***	37 (475)	0 (18)	4 (64)	1 (48)	5 (50)	0 (2)	0 (48)	0 (12)
Oct. 24	0 (438)	0 (55)	0 (60)	1 (47)	1 (50)	1 (7)	0 (48)	0 (12)
Oct. 26	31 (438)	5 (55)	7 (60)	3 (46)	11 (49)	1 (6)	3 (48)	1 (12)
Oct. 27	4 (407)	0 (50)	1 (53)	0 (43)	1 (38)	1 (5)	2 (45)	0 (11)

* Year in which the mark was applied.

** Numbers in brackets are numbers of marked fish of various kinds available to be caught at the time each haul was made. Numbers of 1953- and 1954-marked fish have been corrected for estimated mortality of 0.584 between seinings of 1954 and 1955.

*** Subsequent to October 21 no further marked fish were released.

from one haul to the next within any single series an essentially constant fraction of the catch consists of the various kinds of marked fish at large. The apparent trend in relative frequency for the 1954 marks among the 1954 hauls is to be explained (below) by the fact that in this year marked fish of the different kinds were released in different ends of the lake. It can be shown that, in a population containing marked and unmarked individuals being exploited at different rates by the same gear, a persistent trend ought to characterize the fraction of marked individuals in the catches of successive units of effort. Such trends might be difficult to detect, particularly in so short a

TABLE 4.—RELATIVE FREQUENCIES OF MARKED FISH IN THE CATCHES OF THE VARIOUS HAULS

Date	All Marks	1953 Marks	1954 Marks	1955 Marks
1953				
Nov. 17	——	0.022 (0.016–0.028)*	——	——
1954				
Mar. 18	——	0.040 (0.031–0.050)	——	——
Mar. 19	0.071 (0.046–0.095)	0.061 (0.038–0.084)	0.010 (0.000–0.019)	——
Mar. 23	0.094 (0.091–0.097)	0.027 (0.022–0.032)	0.067 (0.060–0.074)	——
Mar. 24	0.113 (0.070–0.157)	0.034 (0.009–0.060)	0.079 (0.042–0.116)	——
Mar. 29	0.102 (0.088–0.116)	0.023 (0.016–0.030)	0.079 (0.066–0.092)	——
Mar. 30	0.093 (0.007–0.179)	——	0.093 (0.007–0.179)	——
Mean for 1954		0.031 (0.027–0.035)	0.071 (0.064–0.077)	
1955				
Oct. 19	——	0.006 (0.000–0.016)	0.039 (0.017–0.061)	——
Oct. 20	——	0.012 (0.004–0.019)	0.046 (0.032–0.061)	0.021 (0.011–0.031)
Oct. 21	0.243 (0.179–0.307)	0	0.029 (0.004–0.054)	0.214 (0.153–0.275)
Oct. 24	0.091 (0.000–0.261)	0	0.091 (0.000–0.261)	0
Oct. 26	0.173 (0.127–0.219)	0.012 (0.000–0.025)	0.039 (0.015–0.063)	0.122 (0.082–0.162)
Oct. 27	0.259 (0.094–0.425)	0.074 (0.000–0.172)	0.037 (0.000–0.108)	0.148 (0.014–0.282)
Mean for 1955		0.010 (0.006–0.015)	0.042 (0.033–0.052)	

* Numbers in parentheses are 0.95 confidence limits.

series as six hauls; nevertheless, there is at least no evidence for their existence here.

It is of particular interest to compare the recovery of the 1953-marked fish in the second haul of 1953, immediately after they were released, with their recovery in the seinings of 1954, several months later. The relative frequency of these fish in the catch of November 17, 1953 is 0.022 (0.016–0.028. The confidence ranges presented here and elsewhere in the text correspond to a probability of 0.95). Combining information from the six hauls of 1954, one obtains a total relative frequency for these same fish of 0.031 (0.027–0.035). The overlapping confidence ranges in the two instances make it unnecessary to postulate a change in the relative catchability of these fish over the winter. Comparison of the 1953 frequency with those from selected single hauls of 1954 would have to be extremely complicated in taking into account also the lack of any change whatsoever in the catchability of the 1954-marked fish through the same series of hauls. Thus it seems best not to attempt to formulate one without further information, drawing instead the less complicated inference, permitted by the data, that the behavior of the fish marked in 1953 and 1954 was the same and that the infrequent apparent changes in catchability are due to statistical fluctuation only. It then follows that there were no biases affecting the recovery of marked individuals.

There is an obvious and significant decline in the relative frequencies of fish marked in 1953 and 1954 from the catches of 1954 to those of 1955, 19 months later, the 1953 marks having dropped from 0.031 of the catch to 0.010 and the 1954 marks from 0.071 to 0.042. Such a situation could have been produced by a change in catchability of the marked fish between the two seinings, by recruitment to the unmarked part of the population or by an increased mortality among the marked fish. In this case, the discrepancy is most easily explained not as due to different catchability among marked fish or to difference in mortality between marked and unmarked fish, but as due to recruitment to the unmarked part of the population over the relatively long interval between the seinings of 1954 and 1955. The reasons for drawing this conclusion will appear below.

Elsewhere in the discussion some additional circumstantial evidence will be presented to support the general conclusion that mutilations of the kind we have used do not make the probabilities of capture of the various marked fish different from that of the unmarked ones.

Catchability of Different Marks.—In order to distinguish among several groups of marked fish, it has been necessary to remove several different fins. Thus we have used fish lacking the dorsal lobe of the tail, the anal fin, one or the other of the pelvic or pectoral fins, or lacking various combinations of these. These different mutilations are compared in Table 5, which gives the exploitation rates for the various mutilations caught in each haul. Fish lacking either right or left pelvic fin have been lumped in the table. The behavior of fish bearing the different marks seems to be completely homogeneous within any single haul, thus the kind of mutilation apparently had no effect upon the visibility of the mark (causing the observer to miscount the numbers of marks recovered) or upon the responses of the fish (changing the observed rate of capture by enabling certain marked individuals to escape more easily than others).

Recognition of Old Marks.—By the time they were recaptured in 1955, those fish originally marked in 1953 and 1954 had been at large for from 19 to 24 months. During this time, the shortened fins regenerated to a considerable extent. The regenerated pelvic fins were not difficult to recognize: the regenerated fin was smaller than its uninjured opposite and had crooked or obviously deformed rays. Regenerated anal fins were more difficult to recognize, but were also smaller than normal and also showed abnormal rays. Many of the caudal lobes seemed to have regenerated quite perfectly with regard to size, and the replaced rays were not obviously different from the normal rays in the uninjured ventral lobe. However, a sharp line demarcating the cut edge of the old fin could be seen quite clearly if the fin were placed against a light background.

Since closer examination was generally required to recognize certain of the old marks, it is possible that biases have been

TABLE 5.—EXPLOITATION RATES FOR THE MARKED FISH IN THE VARIOUS HAULS

Date	1953 Caudal	1953 Anal	1954 Right or Left Pelvic	1955 Pectoral
1953				
Nov. 17	0.093 (0.058–0.126)*	0.058 (0.029–0.088)	——	——
1954				
Mar. 18	0.193 (0.137–0.250)	0.147 (0.094–0.199)	——	——
Mar. 19	0.058 (0.023–0.094)	0.092 (0.049–0.199)	——	——
Mar. 23	0.342 (0.255–0.429)	0.432 (0.324–0.541)	0.347 (0.309–0.386)	——
Mar. 24	0.028 (0.000–0.057)	0.048 (0.000–0.095)	0.029 (0.015–0.043)	——
Mar. 29	0.223 (0.136–0.311)	0.200 (0.100–0.300)	0.250 (0.209–0.290)	——
Mar. 30	0	0	0.010 (0.001–0.019)	——
1955				
Oct. 19	0	0.074 (0.000–0.185)	0.073 (0.030–0.116)	——
Oct. 20	0.182 (0.030–0.333)	0.160 (0.000–0.320)	0.263 (0.184–0.342)	——
Oct. 21	0	0	0.045 (0.009–0.080)	0.078 (0.055–0.101)
Oct. 24	0	0	0.009 (0.000–0.028)	0
Oct. 26	0.074 (0.000–0.185)	0.048 (0.000–0.143)	0.094 (0.038–0.151)	0.071 (0.048–0.094)
Oct. 27	0.080 (0.000–0.020)	0	0.010 (0.000–0.031)	0.010 (0.000–0.020)

* Numbers in brackets are 0.95 confidence limits.

introduced into some of the calculations as a result of disproportionate miscounting of old marks. Table 6 compares the numbers of fish bearing an old mark caught in 1955 with the numbers of marked fish of various kinds left in the lake after the spring seining of 1954. The expected numbers captured are computed by apportioning the total number of old marks captured among the 3 classes according to the relative abundances of the 3 kinds of marks in the population of spring, 1954. Agreement between expected and observed values is close, indicating that apparently all of the old marks were recognized with equal precision. This conclusion is contingent upon the fact that all of the marked fish were subject to the same rate of mortality through the period between the hauls of 1954 and 1955; the result may be looked upon as evidence also for equality of mortality among all of the marked fish left in the lake in 1954.

TABLE 6.—RELATIVE CATCHABILITIES OF FISH MARKED IN 1953 AND 1954 IN HAULS OF 1955

Mark	Number Left in Population after Spring Hauls, 1954	Number Caught in Fall Hauls, 1955	Number Expected to be Caught, Fall Hauls	Chi²
Either pelvic	396	69	65.9	0.1458
Anal	51	7	8.5	0.2647
Dorsal lobe of caudal	70	10	11.6	0.2207
Total	517	86	86.0	0.6312*

* $P = 0.73$.

Experience and Catchability.—A factor likely to be responsible for differences in catchability between the marked and unmarked parts of the population is experience, in the sense that a fish caught, tagged and released might be more or less easily captured because of a learned reaction to the gear than a fish never before taken. It is not possible to say in advance what effect such reaction would have on the results, i.e., it could be alleged either that a fish, once caught, would become more wary with experience and harder to recapture, or that the fish actually caught and tagged are representative of the most easily captured part of the population and would therefore be

recaptured later with more ease than the individuals never before taken.

During the last three hauls of the seining of 1955, which together yielded 293 fish, there were several groups of tagged fish in the lake, each with slightly different experience, including fish left from the seinings of 1953 and 1954 and never recaptured, others recaptured once or twice previous to the fourth haul of 1955, still other fish, marked in 1955 and not before recaptured, and captured once before the fourth haul. In Table 7 all of these have been arranged into three groups containing fish recaptured for the first, second and third time during the last three hauls. The fractions actually captured of the numbers of each of these available in the lake before the fourth haul are shown in the table. Although the exploitation rates seem to increase with increased frequency of recapture, the differences are not significant from one group to another, thus there is no direct evidence that catchability changes with increasing "experience" with the gear.

TABLE 7.—EXPLOITATION RATES FOR FISH CAPTURED FOR THE FIRST, SECOND OR THIRD TIME IN THE LAST THREE HAULS OF 1955

Experience	Number Caught	Number Available	Exploitation Rate
First recapture	48	536	0.090 (0.066–0.113)*
Second recapture	19	117	0.162 (0.092–0.233)
Third recapture	3	7	0.429 (0.000–0.910)

* Numbers in brackets are 0.95 confidence limits.

All together, these data leave much to be desired with regard to their ability to demonstrate an effect of experience on catchability, and should be viewed in relation to the remarks made above on the relative catchabilities of the various kinds of marks. In order to recognize fish repeatedly recaptured, it was necessary to mark them by removing successively more and more fins, and thus very possibly to damage in a progressive way their ability to move and avoid capture. If significant differences had indeed appeared, it would have been impossible to assign one or the other of these causes without confusion. Having used only numbers of fish recaptured once in the calculations given below, we are not vitally concerned with this difficulty, nor with the effects of experience or multiple marking.

Movement of Marked Fish.—Recoveries of marked fish released after each of the first two hauls of 1954 may be used to examine the extent and rate of mixture of fish across the arbitrary boundary between the east and west ends of the lake. Marked fish released after either of the first two hauls were marked distinctively and released in the end of the lake in which they were originally caught. In the complete absence of mixing, catches thereafter from either end of the lake should have contained fish bearing only one kind of mark. The data in Table 8 show that this was not the

TABLE 8.—EXPECTED AND ACTUAL NUMBERS OF CAPTURES OF 1954-MARKED FISH IN THE TWO ENDS OF LAKE WINGRA

Date	Left Pelvic (Released in West End)		Right Pelvic (Released in East End)	
	Expected	Captured	Expected	Captured
1954				
March 19	15.8*	4	—	—
March 23	163.7	166	145.0**	126
March 24	7.6	8	7.3	8
March 29	62.6	65	60.0	68
March 30	1.6	4	1.5	0
1955				
All west hauls	16.3	17	13.7	11
All east hauls	18.6	15	18.9	26

$X^2 = 3.926$, $P = 0.40$

* The 0.95 range of expected values is 8.1–23.5.
** The 0.95 range of expected values is 122–168.

case. The extent of the mixing that undoubtedly occurred may best be described by comparing the actual recoveries of marked fish of the two kinds with the re-

coveries to be expected in a situation in which complete instantaneous random mixture occurred following the release of each lot of marked fish. This comparison is made in the upper part of Table 8. In each case, the expected number of marked fish recovered is computed from the fraction of the total available population taken in each haul and the known numbers of marked fish at large before each haul.

Agreement between expected and actually captured numbers of fish is almost perfect throughout the table except for those hauls immediately following the release of marked fish; in these instances there is a tendency for the number of fish actually caught in the end of the lake *other* than the one in which they were released to be slightly smaller than the number expected under conditions of instantaneous mixing. The results in general suggest that in less than 26 hours (interval between release of marked fish after the haul of March 18 and the closing of the net for the haul of March 19) complete mixing does not take place, but that after a period of about 3.5 days (between the release of fish following the haul of March 19 and the closing of the net for the haul of March 23) a free random exchange of fish between the two ends of the lake has been accomplished.

The same groups of marked fish, when captured in 1955 after having been at large for some 19 months, showed no tendency toward segregation in particular ends of the lake. This is shown clearly if the actual numbers of fish marked in 1954 and captured in the two ends of the lake are compared with expected numbers obtained by distributing the total numbers of 1954 marks caught in 1955 according to the total catches made in the two ends (in Table 8, lower part).

We have concluded from these results that strong tendencies toward localization or homing do not characterize these fish, and that, given sufficient time, the marked fish will mix randomly with the unmarked part of the population. It can also be observed in this connection that the release point is probably of little importance in affecting the exploitation rates of the released fish in subsequent hauls provided at least three days intervene between release and recapture.

MORTALITY

Mortality between the last fall seining of 1953 (November) and the spring seinings of 1954 (March) may be measured with data provided by the catches of the last four spring hauls. In these, combined, 6,298 fish were caught, including 445 bearing one or the other of the spring-applied marks. At the time the third haul was begun, there were 841 fish at large bearing such marks; the exploitation rate applied to the population by the last four hauls was, therefore, $445/841 = 0.53$. In November of the preceding year 560 fish had been marked, and of these 43 were removed from the lake in the catch of the last haul of that seining, leaving 517; 94 others were removed during the first two hauls of 1954, after an unknown number had died during the winter. Under such circumstances, the crude rate of mortality for the 4-month period would be given by

$$K = 1 - \frac{n + ra}{rb} \qquad \ldots(1)$$

where K is the crude mortality rate

- a is the number of marked fish removed in the first two hauls of 1954
- b is the number of marked fish left in the lake at the conclusion of the seining of 1953
- r is the exploitation rate realized during the last four hauls of 1954, and
- n is the total number of 1953 marks caught in the last four hauls of 1954.

For these four winter months, K proves to be 0.219. Since the logarithm of the survival rate for n months is n times the logarithm of the mean monthly survival rate, we obtain 0.060 as a mean monthly mortality rate for these four months. The term "mortality" in this context implies any loss, due to death, emigration or other cause, from the catchable population, exclusive of losses due to the fishery itself.

In an exactly similar way, mortality during the almost 19 months between the last haul of 1954 and those of 1955 may be measured in terms of the recaptured fish in the catches of the last four hauls of 1955. At the time the third haul of the 1955 series was begun, there were 475 fish in the lake bearing marks applied in 1955; in the last four hauls, 72 of these were captured. The ex-

ploitation rate for these four hauls was 72/475 = 0.15. At the conclusion of the seining of 1954, 396 fish bearing the 1954 mark were in the lake; 52 of these were caught in the first two hauls of 1955 and 17 in the last four. Applying (1) we obtain a crude mortality rate of 0.577. Another computation may be made using returns of fish marked in 1953, of which an estimated 120 remained after the hauls of 1954, 12 being taken in the first two hauls of 1955 and 5 in the last four. The crude mortality rate obtained from these is 0.611. The two results are close enough to average; lumping information for both groups of marked fish and applying (1), we obtain the weighted average 0.584, which is equivalent to a mean monthly rate of 0.045.

Assuming that there are four months each year characterized by a "winter" mortality rate, and eight characterized by a "summer" rate, we can calculate the latter by using 0.060 as an estimate of the "winter" rate and adjusting the 0.045 by noting that this applies to a period of 18.6 months, of which 4 are "winter" and 14.6 "summer." The final results give a mean monthly "winter" mortality rate of 0.060 and a mean monthly "summer" rate of 0.041.

ESTIMATES OF POPULATION SIZE

Forty-three of the 560 carp marked after the first haul of 1953 were captured in the second haul; these included 28 with caudal and 15 with anal mutilations. The mean exploitation rate for the second haul was therefore 0.08, and the population of catchable fish in the lake before the second haul is estimated by dividing the total catch of that haul by this value. Estimates based upon returns of caudal and anal marks and upon these combined are given Table 9; populations before the first haul and after the second are obtained by adding the catch of the first haul and subtracting that of the second from the estimate, correcting for any tagged fish returned. The estimates have been converted to standing crops in pounds per acre by applying data on average weight from Table 1 and the area of the lake (320 acres). It is apparent that the same result is yielded by the two kinds of mark; in the remainder of this paper we have lumped returns of different marks applied during the same series of hauls, having found no indication that the kind of single mark affects catchability (see above).

Estimates of the population of carp based upon marked fish recovered in 1954 and computed for each haul of that year appear in Table 10. As the table shows, such estimates may be made in two essentially independent ways. During the last four hauls of 1954, 0.53 of the marked fish released after the first two hauls were recaptured. Dividing the total catch of the last four hauls by this exploitation rate gives 11,883 as an estimate of the size of the population present before the third haul; subtracting or adding to this figure the known catches of the other hauls provides estimates of the sizes of populations present before each of the hauls, and indicates that 5,585 fish remained in the lake at the conclusion of the 1954 seining. Recovery of the older marks (those from 1953) during the last four hauls provides no additional information; the number of these available at the beginning of the third haul could be obtained by multiplying the number known to have been left in the lake in 1953 by the estimated survival rate between November and March and then subtracting the numbers taken in the catches of the first two hauls. But since estimation of the survival rate depends only upon exploitation of the 1954 marks, the exploitation

TABLE 9.—SIZE OF THE POPULATION IN 1953

Time	Number of Fish			Pounds per Acre
	Caudal	Anal	All Marks	
Before first haul	—	—	27,837 (20,301–41,585)*	407 (299–604)
Before second haul	20,911	33,408	25,272 (17,736–39,020)	362 (254–559)
After second haul	—	—	23,321 (15,785–37,069)	334 (226–531)

* Numbers in brackets are 0.95 confidence limits.

rate for older marks corrected for mortality will also be precisely 0.53. Thus, confidence limits for the estimates of population size must here be based only upon the numbers of recaptured 1954 marks.

However, the estimated residual population of 1953 may be corrected for mortality and for the numbers of fish removed in 1954, giving an estimate comparable with but not dependent upon the estimate made above. Confidence limits for an estimate of this kind are difficult to obtain; a *minimum* 0.95 confidence range may be attached simply by carrying the limits of the estimate of the population of 1953 through the computation, assuming (incorrectly) that the survival rate is a constant given without error. These are the limits shown in Table 10. Though not exact, they are valuable for purposes of comparing the two independent estimates, which prove not to differ significantly. It is implied by this agreement that the computed correction for mortality is accurate and that it applies equally to marked and unmarked fish; it is also implied, rejecting the possibility that varying mortality, recruitment and catchability are perfectly intercompensating, that no recruitment occurred between the seinings of 1953 and 1954.

TABLE 10.—SIZE OF THE POPULATION IN 1954 AS NUMBER OF FISH PRESENT BEFORE HAULS MADE ON EACH OF THE DATES GIVEN

Time	Computed from Recovery of 1954 Marks	Computed from Depletion of Residual Population of 1953
March 18	13,160	17,369
March 19	11,899	16,108
March 23	11,883	16,092
	(10,859–13,121)*	(10,206–26,829)**
March 24	7,517	11,726
March 29	7,314	11,523
March 30	5,628	9,837
Left at conclusion of 1954 hauls	5,585 (4,561–6,823)*	9,794 (3,908–20,531)**

* Exact 0.95 confidence limits.
** Minimum 0.95 confidence limits (see text).

Essentially the same procedure may be used to estimate the size of the population in 1955. The total catch of the last four hauls of this series may be divided by the exploitation rate for those hauls computed from recapture of fish marked during the first two hauls (0.15), or the residual population of 1954 may be corrected for mortality and depletion, as above. These estimates are given in Table 11. The same comments regarding confidence limits are apposite in this instance.

TABLE 11.—SIZE OF THE POPULATION IN 1955 AS NUMBER OF FISH PRESENT BEFORE HAULS MADE ON EACH OF THE DATES GIVEN

Date	Computed from Recovery of 1954 Marks	Computed from Depletion of Residual Population of 1954
Oct. 19	3,697	1,746
Oct. 20	3,697	1,746
Oct. 21	3,107	1,156
	(2,589–3,883)*	(730–1,671)**
Oct. 24	2,981	1,030
Oct. 26	2,970	1,019
Oct. 27	2,715	764
Left at conclusion of 1955 hauls	2,698 (2,170–3,464)*	737 (311–1,252)**

* Exact 0.95 confidence limits.
** Minimum 0.95 confidence limits (see text).

Here the difference between the two estimates (3,107 and 1,156) is large enough to require an explanation; the difference is not unexpected in view of the changes in relative frequency of the marked fish from 1954 to 1955 alluded to above. Again, three primary sources of error, greater mortality among the marked fish than among the unmarked, a higher rate of capture among the unmarked fish than among the marked or recruitment to the unmarked part of the population, are of concern. Of these, the first two may be considered to have been eliminated as possibilities by data presented above. When the same mortality rate was applied to marked and unmarked fish in computing the size of the population in 1954, the results were consistent with an estimate obtained without recourse to a correction

for mortality. In that instance, four months elapsed between the seinings; if no demonstrable increase in mortality appeared during this period as a result of marking, it does not seem likely that one would have appeared by the end of the 19-month period that intervened between the seinings of 1954 and 1955. That is to say, if marking were to cause increased mortality among marked fish, one might expect that the increase would be evident soon after removal of the fins, before the wounds had healed and while the fish were susceptible to infection. Thus, in order to explain the discrepancy in terms of changed mortality, one might be obliged to accept also the conclusion that the difference in mortality had waited four months before appearing. On the other hand, though there is no evidence for recruitment during the shorter period, the possibility is not thereby eliminated that at least during the warmer months of the longer period, growth resulted in recruitment to the unmarked part of the catchable population. The problem of differentially-catchable marked and unmarked fish has already been discussed.

We have tentatively accepted the hypothesis that recruitment is responsible for the discrepancy in the two estimates, realizing that the data in hand do not make it possible to eliminate mortality unequivocally as a contributing factor.

An exhaustion method might have been used for estimation of population size within each of the series of replicated hauls, provided it could have been assumed that each of the hauls applied a uniform unit of fishing effort to the population, i.e., that each haul captured the same fraction of the population available at the beginning of the haul (cf. DeLury, 1947). Ordinarily it is useless to attempt the application of such a method to the catches of hauls made over a long period, during which natural mortality and recruitment are likely to change the size of the population; the method does not permit the simultaneous estimation of rates of mortality and recruitment and population size. Applying a simplified version of DeLury's calculation to the results of the two hauls of 1953, one may write

$$N = \frac{C_1^2}{C_1 - C_2} \qquad \ldots (2)$$

where N is the size of the population before the first haul, C_1 is the number of fish caught in the first haul and C_2 is the number caught in the second. Here N proves to be 8,345, a much lower value than that based upon the recapture of marked fish (see Table 9). An inspection of the catches of the replicated hauls of the seinings of 1954 and 1955 (Table 1) leads one immediately to the conclusion that attempts to apply an exhaustion method there would produce only the most imprecise estimates, a result of the great and irregular fluctuations in the catch per haul. Table 12 contains exploitation rates realized in the various whole- or half-lake hauls; it is immediately obvious that the assumption of uniform effort for each haul cannot be maintained.

RECRUITMENT

The difference between the two discrepant estimates of the size of the population before the hauls of 1955 (3,107 – 1,156 = 1,951) may be taken as a preliminary estimate of the number of newly recruited fish present in the 1955 population. Using slightly different data, this number may be estimated also from the relation

$$p = \frac{km}{kb' + x} \quad \text{or}$$

$$x = \frac{km - pkb'}{p} \qquad \ldots (3)$$

where m is the number of fish bearing 1954 marks left in the lake at the conclusion of the 1954 hauls,

b' is the total number of fish left at the conclusion of the 1954 hauls,

p is the ratio of 1954 marks to total catch for all hauls of 1955,

k is the total survival rate for the 19-month period between hauls of 1954 and 1955, and

x is the number of newly recruited fish present in the population immediately before the hauls of 1955.

Using for b' the estimate with the narrowest confidence range (5,585), we obtain x = 1,595, which is in reasonably close agreement with the 1,951 obtained independently above. A mean monthly recruitment for the 19-month period may now be computed as follows. In a population in which recruitment is uniform with time, i.e., in one where behavior can be described by the equation

$$\frac{dN}{dt} = \alpha - \kappa N$$

where α and κ are constants, change in size with time will be described by the expression

$$N = \frac{\alpha - (\alpha - \kappa N_o)e^{-kt}}{\kappa} \quad \ldots (4)$$

where N is the size of the population at time t, N_0 is the size when $t = 0$ and a and κ are instantaneous rates of recruitment and mortality. The value of a may be looked upon as a mean rate of recruitment if the newly recruited individuals are subject to the same rate of mortality as the older ones, or as the total number of individuals added to the population in one unit of time disregarding whether or not they survive to the end of the period.

We have assumed above that recruitment does not occur throughout the year; thus, the history of the population from about April 1, 1954, may be divided into three periods, the first, April 1, 1954, to November 1, 1954, in which recruitment occurs and in which the population is subject to a monthly mortality rate of 0.041, the second, November 1, 1954, to March 1, 1955, in which there is no recruitment and in which the monthly mortality rate rises to 0.060, and the third, from March 1, 1955, to the seining of October 1955, in which recruitment occurs and in which the mortality rate is again 0.041 per month. Using the above information, one may calculate the instantaneous rates of mortality on a monthly basis, obtaining $\kappa = 0.062$ for the "winter" period and 0.042 for the "summer" ones. Substituting these and the known population sizes in March 1954 and in October 1955 into (4) and then solving successively for each of the periods, one obtains $\alpha = 193.8$ for the instantaneous rate of recruitment on a monthly basis (the number of fish added to the population per month during the months in which recruitment occurs, irrespective of their survival to the end of the month).

We have assumed that recruitment occurs during eight months in the year; at 193.8 per month, 1,550 fish will have been added in the course of a year. Table 13 shows the calculated sizes of the population in Lake Wingra at the end of each of the three periods described above. The table has been extended somewhat at the bottom, using as a starting value the number of fish estimated to have been left in the lake at the conclusion of 1955 seinings, to indicate the trend in size that would characterize it for the next several years *provided the current rates of mortality and recruitment continue unchanged.* It is interesting to notice that the residual population after the seinings of 1955 is close to the steady-state size determined by the rates of mortality and recruitment that characterized it at that time, i.e., there would be expected only a slight increase from a residual November population of 2,698 to a steady-state value in fall of about 2,900. Spreading the annual recruitment of 1,550 fish uniformly over 12 months instead of over 8 changes the steady-state size but little, simply reducing the fluctuation from spring to fall (second column of Table 13). The values given for

TABLE 12.—TOTAL EXPLOITATION RATES REALIZED IN THE VARIOUS WHOLE- OR HALF-LAKE SEININGS

Date	Available Population	Catch	Exploitation Rate
1953			
Nov. 13 (whole lake)	27,837	3,125	0.112
Nov. 19 (whole lake)	25,272	1,951	0.077
1954			
Mar. 18 (west half)	13,160	1,711	0.130
18 + 19 ("whole" lake)	13,160	2,122	0.161
Mar. 23 (west half)	11,883	4,366	0.367
23 + 24 ("whole" lake)	11,883	4,569	0.384
Mar. 29 (west half)	7,314	1,686	0.231
29 + 30 ("whole" lake)	7,314	1,729	0.236
1955			
Oct. 19 (west half)	3,697	307	0.083
Oct. 20 (east half)	3,697	860	0.233
Oct. 21 (west half)	3,107	173	0.056
Oct. 24 (east half)	2,981	11	0.004
Oct. 26 (west half)	2,970	255	0.086
Oct. 27 (west half)	2,715	27	0.010

TABLE 13.—SIZE OF THE POPULATION AT VARIOUS DATES

Date	Summer Recruitment Only	Recruitment throughout the Year
April 1, 1954	5,585*	—
November 1, 1954	5,338	—
March 1, 1955	4,164	—
October 19, 1955	4,274*	—
November 1, 1955**	2,698*	2,698*
March 1, 1956	2,104	2,536
November 1, 1956	2,787	2,662
March 1, 1957	2,174	2,508
November 1, 1957	2,836	2,643
March 1, 1958	2,212	2,493
November 1, 1958	2,863	2,632

* These values are estimates made directly from returns of marked fish; other numbers are computed from equations given in the text.

** After seining.

the years beyond 1955 are, of course, pure fictions; there is no guarantee that recruitment or mortality will not have changed.

FINAL REMARKS AND DISCUSSION

A peculiarity of this population that has become quite apparent by this time is that throughout the period of heavy exploitation after 1953 it did not respond with compensatory recruitment to the great reduction in size brought about by natural mortality and the fishery. Such recruitment as was observed may perhaps be explained most simply as the result of growth into the catchable size-range of a relatively small number of fish belonging to the same age groups as the catchable members of the population; the population has behaved generally as though it were a nonreproducing group of fish containing a number of adjacent age groups, only a relatively small fraction of which was originally not vulnerable to the gear because of small size. Samples of smaller fish collected in Lake Wingra with gill net, fyke net, minnow seine and trawl during 1954, 1955 and 1956 consistently failed to contain young carp, although some of these same devices used in 1945 and 1946 caught large numbers of carp younger than one year.

It has been observed previously (by Mraz and Cooper, 1957) that among carp held over the breeding season in small ponds there is no relationship between density of the adult population and number of young produced and surviving to the end of the first summer; it is well known that among other species of fish there is seldom a close dependence of reproductive success upon adult density (*see* Ricker, 1954), least of all a close inverse one. There seems to be no possibility at the present time of assigning the reproductive failure among the carp in Lake Wingra to a specific cause, nor is it possible to say whether or not other carp populations tend to show the same behavior. There is some evidence to suggest that carp populations in other lakes in southern Wisconsin are characterized by periodic changes in age structure (cf. Threinen, 1952), thus, by implication, by great contrast in size between strong and weak year-classes; but no general study of the phenomenon has been made, and no author has attempted to identify a density-independent determinant of reproductive success that could be responsible.

In Lake Wingra, the failure of reproduction throughout the period in which the fishing was applied made it quite easy to reduce the size of the apparent total population by repeated seining, such that a substantial degree of "control" was actually achieved by 1955. It remains to be seen from the results of future investigation how long the effect may be expected to last, and in what pattern resurgence of the population occurs.

It now remains only to make one or two comments on the economics of the control operation itself. A quantitative history of the population from 1953 to 1955 is given in Table 14, where an attempt has been made to compare the losses due to natural mortality with those due to the fishery. During the period after the fall seining of 1953, about 40,000 pounds of fish were lost from the population as a result of natural mortality, and about 40,000 pounds were recovered in the seining operations. It is evident that, had the seining been pressed in 1953 by concentrating at that time all the effort expended later, a much larger fraction of the total potential yield from the population as it stood after the seining of 1953 would have gone into the catch, and losses from natural mortality would have been correspondingly reduced. The degree

TABLE 14.—QUANTITATIVE HISTORY OF THE POPULATION FROM 1953 TO 1955

	Number of Fish	Weight, Pounds			Pounds per Acre
		Standing Crop	Yield	Mortality	
Population before seining of 1953	27,837	132,782			414.9
Removed by fishery in 1953	4,516		21,541		67.3
Population after seining of 1953	23,321	111,241			347.6
Natural mortality, winter of 1953–54	5,107			23,492	73.4
Population before seining of 1954	13,160	59,746			186.7
Removed by fishery in 1954	7,575		34,390		107.5
Population after seining of 1954	5,585	25,356			79.2
Natural mortality, spring 1954 to fall 1955	3,262			16,310	51.0
Catchable fish recruited, spring 1954 to fall 1955	1,773	7,978			24.9
Population before seining of 1955	3,697	21,276			66.5
Removed by fishery in 1955	1,009		5,337		16.7
Remaining after seining of 1955	2,698	15,527			48.5
After seining of 1953:					
Total loss through natural mortality				39,802	
Total yield to fishery			39,727		

of "control" achieved by 1955, on the other hand, would have been much the same whether all hauls had been made in 1953 or whether they had been distributed through 1953, 1954 and 1955 as was in fact the case, the size to which the population was eventually reduced depending here upon the total amount of fishing effort applied, but not very closely upon its distribution in time. The cost per unit of "control" would have been smaller had the seining been concentrated because the catch per unit of effort would have been greater. Such a conclusion would hold exactly for a population in which there were no recruitment, but wherever equation (4) is taken as a model for the behavior of the population, would become less and less exact as the number of fish recruited per unit of time increased. In this instance, a is small enough to permit the conclusion to stand.

SUMMARY

Rates of natural mortality and recruitment have been investigated in a population of carp inhabiting Lake Wingra, a small hard-water lake in the vicinity of Madison, Wisconsin. The vital statistics were obtained from the results of several tag-and-recapture experiments carried out while the population was heavily exploited by a seine fishery. Average rates of natural mortality were found to be about 0.06 per month during the winter months of November, December, January and February, and about 0.04 per month during the others. During a two-year period in which the population was reduced by about 90 per cent by natural mortality and the fishery, reproduction remained negligible; recruitment to the catchable portion of the population was seemingly due to growth into the catchable size-range of individuals belonging to year-classes already present at the beginning of the period. Various errors affecting the computations are discussed in detail.

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THE PLACE OF CHANCE IN POPULATION PROCESSES

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Various conjectures have been made about the causes of fluctuations in population. A recent suggestion by Palmgren (1949) propounds the idea that such fluctuations are akin to random numbers rather than controlled by either obscure causes or biological processes capable of being analyzed. The obscure-causes concept was ruled out by MacLulich (1937). The theory of random population cycles was worked out in greater detail by Cole (1951, 1954). The present paper is confined to (1) a refutation of the recent overemphasis on the supposedly dominant importance of random numbers and (2) a summary of most of the different ways in which chance does enter into population processes.

Chance alterations to the course of population occur in at least four different ways, as follows:

a) Catastrophic events, floods, fires, eruptions, and storms have a major, unpredictable, and sporadic effect on population. We shall not dwell on catastrophes except to point out one interesting aspect of fortuitous local extermination. In the event of a local population being wiped out by hunting or natural catastrophe, the area may remain unoccupied for years unless man re-introduces the species. This sometimes happens with migratory birds because such birds regularly return mainly to the area of their birth to nest. This is a case of tradition, broken tradition this time; refer to Hochbaum (1946: 407–408) for a discussion of the behavior of certain species of ducks in this regard.

b) Weather that may not appear catastrophic may yet impose a physical limit on animals at a critical time in the life history or at a critical density of population with far-reaching effects such as virtual elimination of an age class. The coincidence of the critical time and the critical weather has an element of chance and a corresponding degree of probability. There is an element of apparent chance in the timing and effect of weather events.

c) Real chance encounters are a necessary step in the life history of some animals, particularly parasites.

d) The genetic composition of a population may alter its proportions drastically when the numbers of the animal are at a low ebb because of the probabilities involved in gene distribution. This may include the emphasis on new mutation or recessive character. Elton (1930) drew attention to this possibility.

Statistical methods, which are based on the laws of probability or chance, are necessary in population studies because of three different situations that are described below. The first is the statistical characteristic of variation within the population and the remaining two are inherent in our methods of measuring and analyzing populations.

a) Individual variability necessitates some statistical treatment of the events in a population in order to assess the accuracy and the amount of variation to be expected.

b) The influence of unknown and/or unspecified causes is commonly collected under the heading of *Chance* and it is hoped or assumed that the net result is in the nature of random numbers or random choice.

c) Sampling errors and errors of measurement of population density and other data are normally assumed to be random and subject to statistical laws and techniques, except for systematic bias. It behooves biologists to use statistical methods to accompany their published results with a statement of the probable accuracy or validity more often than they do.

Statistical methods are used to cope with the variations associated with concepts (*a*), (*b*), and (*c*) above, grouping them usually into one statement of accuracy. Biological data are seldom all that a statistician would desire, being usually of rather coarse accuracy that precludes putting much reliance on small changes. For instance, the field measurements of snowshoe rabbits (*Lepus americanus*) had an accuracy of about plus or minus 40 per cent for scatological data (MacLulich, 1937:38); accuracy of other methods could not be assessed so well. Data

of such coarse accuracy were useful because the changes in population were so much larger than 40 per cent. Trapping-catch or other yield figures tend to be precise absolute numbers giving a false impression of their accuracy as an index of density of population.

RELATIVE RARITY OF CHANCE EFFECTS ON A POPULATION

It is the writer's opinion, as first published in 1937, that the rate of change of population goes through discontinuities, i.e., points of change of process. At these points the dominating control passes from one process or influence to another which takes over. What the new controlling influence shall be depends on the state of the subject population and the situation in the environment. The living elements of the environment, and some physical aspects too, have reached their present state by biological processes rather than by haphazardness or arbitrary jumps in quantity. Their effect, therefore, on the subject population is determined by their history and by orderly phenomena that are gradually being deciphered by scientific investigations. Theoretically there is little of chance in this, but in practice the word is sometimes used to apply to what is yet lacking in our knowledge and understanding. This practice adds nothing to science; it is merely wordy and misleading camouflage. For instance, regarding an epidemic that is the actual cause of death of most of the adults and young of a population, say of rabbits, the specific cause and the time of occurrence of the epidemic are not "due to chance" even if we lack sufficient knowledge to understand how it happens.

THE RANDOM NUMBERS CONCEPT OF POPULATION

The essence of the idea of random fluctuations in population phenomena is absence of logically caused pattern, inferring that the process leading to next year's population is not understood, and not related to previous history. The hypothesis of random fluctuations certainly needs testing against the touchstone of reality as Cole (*op. cit.*) advocates. The hypothesis fails, however, when a biologist shows that the process of reproduction and increase in population is fairly well known and that much is known about causes of decrease in numbers. Examples are Green's data on varying hares or snowshoe rabbits in Minnesota (Green and Shillinger, 1934, and subsequent), my study of the same animal in Canada (1937), Elton and Chitty's series based on Hudson's Bay Company records, Stoddard's (1931) study of quail (*Colinus virginianus*), and numerous others. Wildlife populations develop by biological processes of feeding, reproduction, growth, and so on, hence the reasons for their changes in abundance are to be found in those processes and the natural factors influencing them.

Changes in a series of random numbers have no causes, only the pure chance of drawing any number at all after any other number. A random series then can have any sort of large or small jump from one number to the next and any combinations considered in short groups; but a pattern will not repeat itself continually, other patterns will be interposed. In random numbers a given pattern will recur at irregular intervals and the chance of its reoccurrence can be calculated to have a certain average interval length. Although a certain reoccurrence in random numbers might have the same interval as a certain wildlife recurrent pattern, the variation in length would probably be greater than for the natural population pattern. It is evident that a correspondence between a random and a natural population pattern explains nothing about how or why the animal population behaves as it does.

The thought that chance and random numbers may explain fluctuations in population or imply that chance is the dominant factor has received considerable attention in the literature of recent years. Palmgren (1949) demonstrated that various periodicities could be found in a time series of random numbers and related these to various animal fluctuations as proposed explanations. Siivonen (1950) discussed arguments against this randomness concept. The Foundation for the Study of Cycles publishes *Cycles—A Monthly Report* containing arithmetical and graphical searches for cycles in many fields from animals to stocks or even church membership (*see* Dewey 1953).

The recent "random numbers" approach, while thought-provoking, did overempha-

size chance or randomness and minimize biological knowledge. Cole (1954:3) said: "By the above observations the writer has been led to suspect that population cycles are essentially random fluctuations"; (*ibid.*: 4)—"The writer now feels considerable confidence in the random-oscillation explanation of the 3–4 year population cycle"; and (*ibid.*:19)—". . . such population cycle data as we have today are consistent with the hypothesis that population changes are initiated by purely random fluctuations in environmental conditions." He casts doubt on the existence of the ten-year cycle, saying that many peaks have been ignored; and he demonstrates that, if some minor peaks are ignored in random-number series, one may get any mean cycle length whatsoever, greater than three years. His text indicates that the comparison was being drawn from a rectangular series of random numbers in which any number was equally likely to be drawn.

If random numbers can be shown to duplicate some feature of the record of a natural population, no suspicion is thereby thrown on the record; its validity is determined by the method of measurement and the accuracy that can be demonstrated by statistical means. A resemblance to random numbers should prompt a thoughtful enquiry as to whether or not chance is an integral step in the process. Having answered that, the rest of the process is to be found in orderly natural functions. Note that random actions can result in data that are not distributed at random, as in the case of my compound Poisson distribution described later. Also, just as the statistician could derive by mathematical series a set of orderly data that resemble random numbers, so might the biologist measure a set of orderly population data, the result of known natural processes that resemble random numbers. In both cases there is no conclusion to be drawn from the resemblance.

Let us look for the equivalent of the rabbit cycle in a series of random numbers. The characteristic feature of the pattern is the decrease followed by slow initial increase; hence arises my emphasis in using "the last year of abundance before great decrease" instead of "the peak year" (MacLulich, 1937:16). Hickey (1954:93) noticed that such years were followed by three successive years of decline in the Hudson's Bay Company figures. The pattern can be described by conditions laid down for a group of consecutive numbers in a manner similar to that followed by Cole (1954).

To do this it is necessary to examine the fur returns of the Hudson's Bay Company for records of the "American rabbit" (*Lepus americanus*). For this animal the records are continuous from 1849 to 1904 but there are gaps outside this period. During these 56 years the figures varied from a minimum of about 100 to a maximum of 144,519 skins. For this discussion the fur returns have been expressed as decimal fractions of that maximum and are so shown in Table 1. The growth of population from a minimum is essentially a matter of logistic increase by the reproductive rate under natural conditions in an initially nearly empty environment. Attention will be directed instead to the large, almost catastrophic, decrease that is the characteristic of greater interest because its causes are less well understood. In Fig. 1 all minima, e.g. values smaller than those immediately preceding and following, are shown, each one plotted over a common reference point on the abscissa and connected by a line to the values for the four preceding years and the one year following. It becomes evident by inspection that these minima fall into two classes, those that terminate a large drop from abundance during several years and those that are variations of a much lesser order having no common pattern. Two of these minor variations occurred during the upper part of the growth curve when rabbits were abundant and the other two in the early part of the growth curve following its initial low starting point. The other five minima are the terminations of major decreases, catastrophic and dramatic in their extent. They are also the starting points of new population-growth processes extending over five to seven years before reaching abundance. These five graphs of major decreases allow the formulation of their crude description as follows. Minimum crude description of the large recurring decrease in populations of the snowshoe rabbit:

(*a*) Population indices for five successive years are successively smaller until the minimum is reached at the fourth year.

TABLE 1.—HUDSON'S BAY COMPANY RABBIT (*Lepus americanus*) FUR FIGURES[1]

Year of Biological Production	Number of Rabbit Skins	Decimal Proportion of Maximum	Year of Biological Production	Number of Rabbit Skins	Decimal Proportion of Maximum
1849	15,621	0.108	1877	87,722	0.607
1850	26,781	0.185	1878	65,585	0.456
1851	54,827	0.380	1879	17,593	0.127
1852	82,430	0.571	1880	10,950	0.076**
1853	82,814	0.573	1881	17,830	0.123
1854	91,316	0.632	1882	13,595	0.094**
1855	70,685	0.489**	1883*	29,095	0.202
1856	84,489	0.587	1884*	29,095	0.202
1857	95,534	0.661	1885	53,522	0.370
1858	62,543	0.432	1886	136,726	0.946
1859	29,590	0.205	1887	137,685	0.953
1860	15,409	0.107**	1888	94,150	0.651
1861	18,516	0.128	1889	36,386	0.251
1862	39,258	0.272	1890	22,000	0.152**
1863*	80,257	0.556	1891	50,000	0.346
1864*	80,257	0.556	1892	55,000	0.381
1865	144,519	1.000	1893	65,000	0.450
1866	106,279	0.735	1894	60,000	0.415**
1867	45,909	0.318	1895	80,000	0.554
1868	22,668	0.157	1896	96,000	0.664
1869	631	0.004**	1897	55,000	0.380
1870	3,070	0.021	1898	18,000	0.125
1871	9,932	0.069	1899	5,000	0.035
1872*	33,477	0.231	1900	1,000	0.007**
1873*	33,477	0.231	1901	15,000	0.104
1874	49,053	0.339	1902	100	0.001**
1875	50,934	0.352	1903	5,000	0.003
1876	104,123	0.721	1904	45,000	0.311

[1] Sources are Poland (1892), Seton (1909), and Elton and Nicholson (1942).

For the years 1863, 1872, and 1883, marked *, the skins from Moose River and East Main did not reach England until one year late and were included in next year's sales. To avoid drawing unwarranted conclusions about minima or peaks in these years, the figures for each pair of these years have been averaged here and are marked *. The minima, marked **, are figures smaller than the preceding and following figures.

(*b*) The fourth-year minimum is less than 0.2 of the maximum known.

(*c*) The frequency interval of occurrence of this pattern varies from 9 to 11 years in the 56-year record available above.

The probability of such a pattern as described above occurring in a rectangular series of random numbers may be calculated as is done below. Five successive numbers are drawn. The chance that the first drawn will be the largest is 0.2. Of the remaining four the chance that the last but one will be the smallest is 0.25. To maintain the descending order, the second smallest number must fall in positions three or five, and not in the second position. Of the remaining three numbers the chance of the largest falling in the number two position is 0.33, and it does not then matter which positions the last two fill. However, if the second largest of the last three falls in the number two position, for which the chance is 0.33, the smaller of the last two numbers must fall in number three position, for which the chance is 0.5, and the combined net probability of this combined event is 0.175. The sum of the acceptable probabilities for the positions two, three, and five is then 0.33 plus 0.175 or 0.5. The condition that the fourth-year minimum is less than 0.2 of the maximum known has a probability of $1-0.8^5$

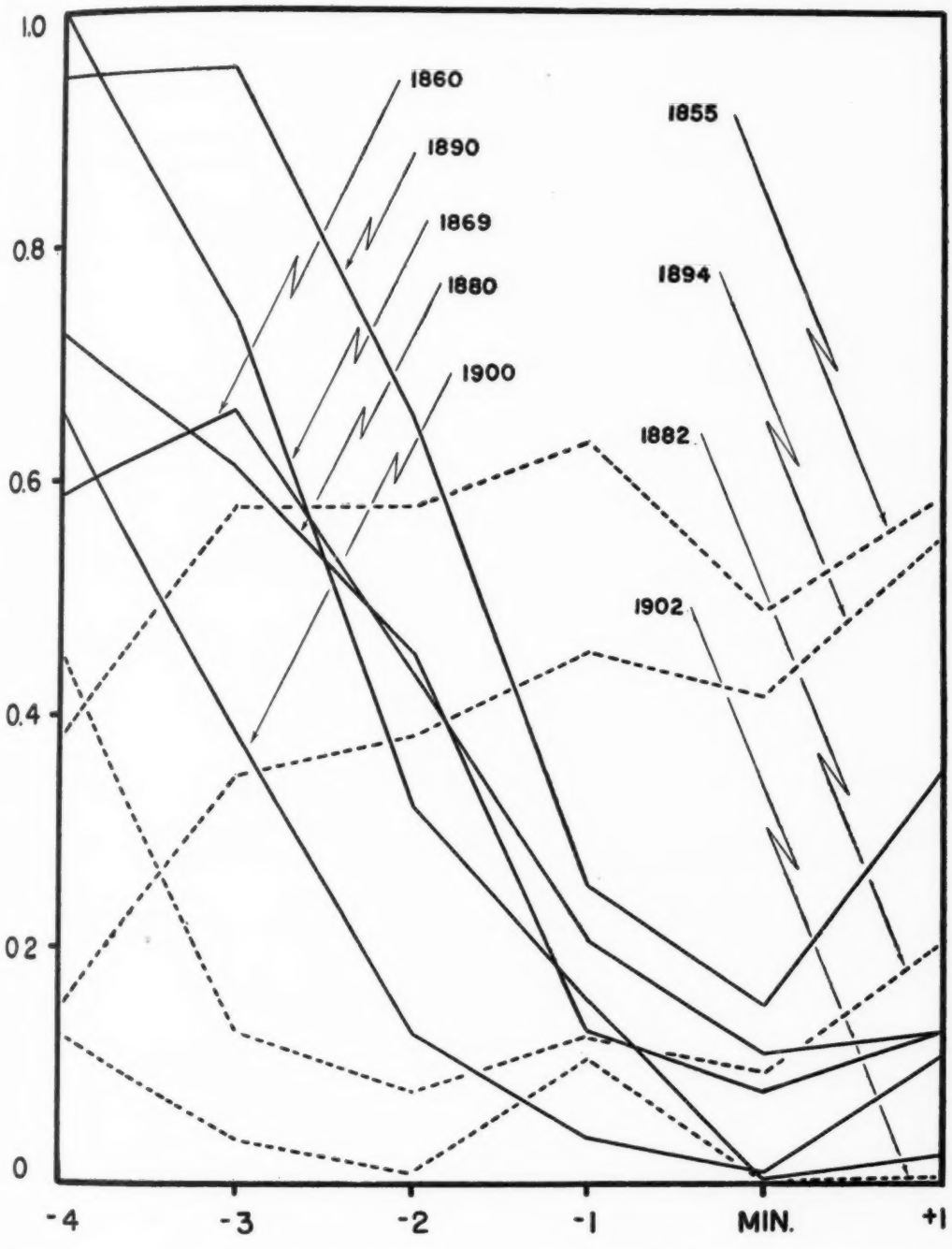

FIG. 1. Minima in the HBC fur data for *Lepus americanus* for the period 1849 to 1904. Major decreases are represented by unbroken lines; minor variations by broken lines. On the ordinant are decimal fractions of the maximum number of rabbit skins produced in 1865 (see Table 1). The number of years before and after each minimum is plotted on the abcissa.

for five numbers drawn, or 0.67. The probability of the pattern occurring as defined by conditions (*a*) and (*b*) is the product, then, of the probabilities 0.2, 0.25, 0.5 and 0.67, which equals 0.017. In a series of *G* numbers there are (*G*–4) groups of five, hence, following Cole (1954), the average length of the recurrence interval is

$$m = \frac{G}{\textit{Probability}\ x\ (G\text{–}4) - 1}\ .$$

For *G* of 56 years the time is too short, and there is no answer; but if a very long series is assumed, the mean interval between recurrences is 59 years. The fact that the rabbit pattern was repeated approximately every ten years instead of every 59 years shows that it bears no resemblance to a rectangular series of random numbers. If only the first condition of three years of decrease to a minimum is considered, the average expected interval is 40 years, which still is not of the same order as the interval for rabbits.

A similar comparison can be made to a normal distribution of chance numbers centered on the average value of rabbit fur returns and spread over a range of plus or minus the size of the average, this range being equated to plus or minus twice the standard deviation of *x*–ordinate in the normal probability integral table. The probability for condition (*a*) will be essentially unchanged at 0.025, because it is a matter of ordering five different numbers after their drawing. The mean is 50,650, and 0.2 of the total range for condition (*b*) is 28,900, or 0.86 below the center of the normal distribution in *x* ordinates. The probability integral for this ordinate is 0.776, hence the area of the curve above this is 0.500 plus $0.776 \times 0.500 = 0.888$. Therefore the condition (*b*) that at least one of the five numbers be below 0.2 of the range will have a probability of $1\text{–}0.888^5 = 0.55$. Combining this with the figure for condition (*a*), the net probability of the pattern occurring is 0.014 and the probable interval is 71 years. This is even more incompatible with the rabbit history.

For observational data the upper limit of the range is related to the carrying capacity of the environment; for instance, in Ontario the mixed country around Buckshot Lake supported a maximum of about 3,400 rabbits per square mile (MacLulich, *op. cit.*), but a heavily forested area of Algonquin Park carried only about one-sixth as many. Observational data show a much steeper decline than do fur returns; at Frank's Bay on Lake Nipissing, Ontario, the estimates dropped from 1,200 to the square mile to 100 to 70 in three successive years, and at Buckshot Lake the numbers dropped from 3,400 in July to 250 in September of the same year to 30, to 0.3, and then zero in the following three years.

Spurious Random Numbers

Many animals go through numerous generations in one year; in such cases a yearly census figure is spaced too far apart to describe the progression of changes in the animal's abundance. Such figures may vary one from the next by as much as the whole range of abundance to scarcity of the animal, or may nearly duplicate the last figure although a variation has occurred between. This sort of census figure, incapable of describing the shape of the changes in abundance, would show greater resemblance to a random-number series. The sampling might be done at a peak or at a minimum or anywhere in between and would be nearly random to that extent. It would reflect an influence emphasized at one period and not in earlier years, or a gradual trend. This is close to what Cole (1954) described when he said: ". . . in species which are capable of great population increases in a single season, it seems logical to accept the year as a natural unit of time and to anticipate a random cycle of about three years." The result could be a set of density figures giving a spurious appearance of random numbers to a population that in reality had a history of orderly changes in response to natural influences and characteristics.

Random Encounters

Chance plays a large part in the distribution of certain parasites to their hosts in cases where neither one seeks out the other but they simply meet at random. In 1939 an example of this sort prompted the writer (1943:411) to devise a distribution, a compound Poisson series, which fitted the population of copepods, *Salmincola siscowet*, on lake trout, *Cristivomer namaycush*. Two assumptions were made: (1) the fish meet

the swarms of infective larval copepods called nauplii purely by chance, and (2) the numbers of parasites picked up by trout in passing through swarms form a random distribution as a first-order assumption. Both assumptions are, therefore, described by Poisson series. The net result is a series that allows for the known swarming of the nauplii and the two assumptions above. The excellent "goodness of fit" was strong evidence that this theory was a first approximation to the truth.

Recently with the help of Eric Leese of the Defence Research Board it has been proven that this distribution is equivalent to and can be converted into Neyman's (1939) "contagious distribution of type A depending on two parameters."

SUMMARY AND CONCLUSIONS

It is impossible to consider adequately the role of chance in living populations without entering into discussion of all aspects of ecology. However, the direct effects of chance in respect to population have been reviewed.

The ecologist starts with biology and environment, i.e., organized observations of animals and their relations among themselves and with their environment, including other animals. He includes chance or random numbers as a nondescript package of remainders, variations, and events inexplicable or unmeasurable by the existing level of scientific knowledge and techniques. He uses inductive reasoning, whereas the statistician using a deductive approach (Solomon, 1949) tends to start with randomness and bring in only such biological knowledge as appears unavoidable. The two viewpoints could come together by the ecologist's acquiring and interpreting full biological knowledge of the situation and the statistician using the same full information in his computations. At this point the role left to chance would in most cases be small.

Unless wildlife data can be proven to be accurate enough to justify it, detailed statistical interpretations of small apparent fluctuations should not be emphasized.

Equations exist that allow for necessary chance encounters with its host as a step in the life history of a parasite.

Random numbers do not explain wildlife population history, and resemblance to random numbers in a population time series has no significance.

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DROPPING BOARDS FOR POPULATION STUDIES OF SMALL MAMMALS[1]

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Most estimates or indices of small-mammal abundance are based on trapping data or sign surveys. Trapping, either with live traps or kill traps, has many desirable features, but is expensive in time and effort and inevitably disturbing to the population. Sign surveys as used by Elton, Davis, and Findlay (1935) or Hayne (1950) avoid these difficulties but are less precise and more dependent on personal variables of skill and interpretation.

A modification of the sign-survey technique which largely avoids these difficulties was suggested by Eadie (1948) in connection with a study of the food habits of shrews. To collect droppings of these animals, he distributed 4-inch squares of paper on the ground. Incidental to this collection of shrew material he noted a high incidence of field mouse droppings on the squares and suggested that "this technique might readily be developed to obtain relative census figures on certain small mammals under uniform conditions with a minimum disturbance to the animals and habitats."

The present paper is a report on a series of studies evaluating the usefulness of dropping stations as a technique for population measurement and analysis of small mammals. The technique to be described involves the distribution of small squares of wood or other weather-resistant material for the reception of fecal droppings. It has been used since 1949 in connection with several small-mammal population studies carried on in the vicinity of Madison, Wisconsin, where the dominant species are *Sorex cinereus, Blarina brevicauda, Microtus pennsylvanicus, Peromyscus leucopus,* and *P. maniculatus.* During these years special tests were conducted to determine ways in which dropping boards could be used most efficiently.

In this report we will first describe the dropping boards and their use in the field, and then consider the problems in recording and interpreting the results obtained, the use of the information as an index to small-mammal populations, and the possible applications of this technique in various types of population studies.

Many students participated in these studies and have contributed to the data reported in this paper. Among these, special mention should be made of Richard Anderson, John Burrington, Eugene Cruse, Frank Iwen, Johanna Jones, John L. Kaspar, Robert Klopman, Charles Louch, Lotus Simon Miller, Carmie Perotta, and Charles Southwick.

Field Procedures

The boards. — Four-inch squares of weather-proofed, ¼-inch, 3-ply plywood proved highly satisfactory for general use and were adopted as the standard in most of the runs. Tests were conducted, however, to determine the effect of various materials, textures, and colors on utilization by the animals. Black boards (dull finish) proved slightly more acceptable than white, but since droppings were much harder to see on the dark boards, these were considered undesirable for general use. The natural tan color of unpainted boards was not so conspicuous as to attract undue attention and was light enough to make droppings readily visible.

Composition boards with a rough surface were compared with the standard type in order to test the effect of surface texture on frequency of use. We thought that the rough surface might help to prevent droppings from being knocked off by the animals in their visits, but the slightly higher inci-

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TABLE 1.—EFFECTIVENESS OF VARIOUS TYPES OF DROPPING BOARDS WITH RELATION TO A STANDARD TYPE (4-IN. × 4-IN. × ¼-IN. WEATHER-PROOFED PLYWOOD)

Type (Variant)[1]	Number Set (Each)	Per Cent Visited		Ratio Var./Sta.	Other Considerations
		Variant	Standard		
Composition board (rough)	500	19	16	119:100	Better retention but harder to see
Fiber (Cellotex)	500	12	12	100:100	
Fiber (Cellotex)	200	48	44	109:100	
Galvanized iron	84	89	90	99:100	Less bulky but heavy
Aluminum (24 gauge)	25	32	40	80:100	Difficult to set firmly

[1] All tests were run by alternating the standard boards with a variant type in lines or grids with 25-foot spacing.

dence of droppings (Table 1) was not statistically significant. Composition boards had the advantage of light weight in transportation, but small droppings, and particularly shrew droppings, were sometimes hard to see on the textured surface, and the danger of overlooking these seemed to outweigh the advantages. A soft fiber board (Cellotex) was contrasted with the plywood boards in two tests. No preference was found (Table 1), and the same difficulties of detecting small droppings were again encountered.

Cardboard and paper squares were not used because of their destructibility in bad weather. The plywood boards stood up well under heavy rain, ice, and snow.

Metal squares were used in several tests (Table 1). Galvanized iron proved to be as acceptable as wood, but the heavy weight was considered undesirable. Light-weight aluminum squares were also acceptable to the animals and were extremely light and convenient for transporting. They also had the advantage of being readily cleaned. The light weight made for some difficulty in setting, however, and many were lost on one occasion in a high wind.

The four-inch-size square seemed satisfactory, but a few runs were made with 8-in. x 8-in. boards. This larger size was quite awkward to handle and produced no greater incidence of use. A slightly greater number of droppings per board was not considered to be of sufficient value to warrant their use in most situations. These boards have a possible value for larger mammals, but a single test in a dump infested with brown rats (*Rattus norvegicus*) was not successful.

Devices for anchoring boards to the ground and for roofing them against rain, snow, and the disturbances of larger mammals and birds were not employed, although such devices may prove desirable in certain situations.

Setting and servicing.—In order to avoid bias and to minimize the personal factor in these tests, boards were set out at designated spots without particular regard to the presence of runways or other mammalian signs. They were placed firmly on the ground in an approximately level position so as to avoid the loss of droppings by tilting. Vegetation was disturbed as little as possible, although in some areas frequent visits to the boards resulted in the trampling of vegetation to one side of the line. In some situations it was necessary to stake or otherwise mark the location of each board, but in many places the conspicuous nature of the board was adequate when the spacing was properly paced off.

The standard procedure adopted in servicing boards was to number each station, record the number and type of droppings at each, and then brush the board clear for the next visit.

The time of day and frequency with which boards were serviced depended upon the conditions prevailing. A standard procedure was desirable for comparative runs, since measurements based on incidence did not vary proportionately with the duration of exposure (Table 2). But blind adherence to any single system can lead to marked inefficiencies. During the summer, in areas where coprophagous insects were active, daily servicing was mandatory, and was done in the early morning before such insect activity became great. Daily servicing

TABLE 2. — EFFECT OF SERVICING INTERVAL (3-HOUR, 24-HOUR, AND 72-HOUR) ON INCIDENCE OF VISITS AND NUMBERS OF DROPPINGS IN A SAMPLE LINE OF 100 STATIONS AT MADISON, NOVEMBER 7–10, 1949

	Servicing Intervals[1]		
	3 Hours	24 Hours	72 Hours
No. of periods	24	3	1
No. of visits[2]			
1	71	45	20
2	—	10	7
3	—	2	6
4	—	—	2
5	—	—	1
6	—	—	1
Stations visited[3]	71	57	37
Exposures	2,400	300	100
Incidence (per cent)	3.0	19.0	37.0
Droppings per station	0.052	0.42	1.25
Droppings per active station	1.75	2.20	3.38

[1] All boards were checked and brushed clear every three hours during this 72-hour test.
[2] Occurrence of droppings in any 3-hour period is here considered a single visit.
[3] Stations visited one or more times.

also seemed advisable where small mammals were numerous, since droppings left by one animal were often kicked or rolled off by subsequent visitors. When small-mammal activity was low, however, as in early spring, 48 or even 72 hours were required to provide an adequate sample. Longer exposures produced diminishing returns and may invite complications by storms and other extraneous disturbances.

Distribution and spacing.—Whether the boards should be placed in a line or in a grid pattern depends largely on the type of information sought. For many studies of habitat preference, species association, or food habits a line is satisfactory and most easily operated. Measurements of population density, of local distribution, or of population movements should, however, utilize a grid pattern of distribution.

The distance between boards in a line seemed to have little effect on the incidence or total accumulation of droppings, at least when this spacing was greater than 25 feet. In a comparative test of 100-foot and 25-foot spacings in a series of six 4,500-foot parallel lines in January, 1950, the incidence of visits was 3.7 per cent in the former and 3.9 per cent in the latter. In a series of grids set in a *Microtus* meadow in December, 1951, comparable results were obtained with spacings of 25 feet or more, but a reduction in the incidence of visits occurred with a 12½-foot spacing (Table 3).

At least 100 boards should ordinarily be used to provide a meaningful sample. A grid of 100 boards will cover 1.2 acres with a 25-foot spacing, 4.7 acres with a 50-foot spacing, and 18.8 acres with a 100-foot spacing. Larger numbers of boards are often desirable.

TABLE 3. — EFFECT OF VARIOUS SPACINGS OF DROPPING BOARDS ON INCIDENCE OF VISITS IN A GRID COVERING APPROXIMATELY TWO ACRES IN A *Microtus* MEADOW AT MADISON, DECEMBER 6–12, 1951

Spacing of boards (in ft.)	100	50	25	12½
Number per acre	4	16	64	256
Incidence (per cent)	29	41	35	13

Number of runs per survey.—A run was generally repeated for several successive nights. This was desirable since it increased the size of the sample and at the same time reduced the often unpredictable distorting effects of weather and other variables of a single night's run. A series of three runs is commonly adopted in snap trapping operations and appears to be equally satisfactory for dropping-board surveys. Thus 300 exposures (number of boards × number of servicings) were considered to be a satisfactory minimum for a sample. Larger series provided more complete data and, as noted later, offered opportunities for the study of weather effects.

Repetition over a series of nights revealed that the animals generally found and used the boards the first night. A summation of results from 12 lines from a variety of situations near Madison gave totals of 187, 188, and 184 visits for the first three days of exposure. A line of boards run daily in a *Microtus* meadow through the summer and fall of 1951 showed what would appear to be a continuing stability of response to the boards over an extended period of time, the fluctuations and final downward trend being presumably attributable to variations in weather and to the flooding of the meadow (Fig. 1). With such stability, the duration of a test run for a population index need be limited only by considerations of population change; and continuous operations should prove to be valuable for detecting population fluctuations except as disturbances of wind, rain, snow, or interfering animals occasionally disrupt the series.

Data that might seem to contradict this interpretation were obtained in a test in which 50 boards that had been set out 12 days before servicing were visited about twice as often as 50 boards set out fresh (Table 4). The definite effect of prolonged exposure in this test is considered to reflect a positive response to accumulated droppings and urine rather than to habit formation at the board sites. This interpretation is supported by the fact that the effect was promptly lost when all boards were replaced by clean ones on the eighth day (last column of Table 4). It is also supported by the results of a special test on the attractant characteristics of urine impregnation as described in the next section of this paper.

If we accept this interpretation of the special test summarized in Table 4, we may regard dropping boards as a satisfactory technique for obtaining a continuous record of population trends provided the boards are regularly brushed clean with each servicing.

Use of baits and lures.—Baits or other lures may be placed on boards as they are set out. The value of such materials in increasing the visits of small mammals undoubtedly varies greatly with locality, season, and species, just as it does with traps. Several baits were used in the tests at Madison, and all were found to increase the frequency of visits selectively.

A striking example of response was obtained in a test with peanut butter in the *Microtus* meadow, October 12–26, 1949. In a line of 100 stations spaced at 25-foot intervals, the odd-numbered boards were baited with a dab of peanut butter from the third to the sixth day. These baited boards were exchanged with the unbaited boards at the even sites from the sixth to the ninth day. They were then removed entirely and replaced by clean (new) boards throughout. The results are shown in Fig. 2. Introduction of bait in this test brought an immediate response on the treated boards in both series.

TABLE 4. — EFFECTS OF EXTENDED EXPOSURE (PRE-SETTING) ON ACCEPTANCE AND UTILIZATION OF BOARDS IN A SPECIAL TEST[1]

Days	Incidence (Per Cent)		
	1–3	4–7	8–10[2]
Boards exposed in place 12 days before servicing	38	29	21
Boards set out fresh (controls)	17	15	20

[1] Boards serviced daily November 5–14, 1949, Madison.
[2] All boards were replaced by clean new boards on the eighth day.

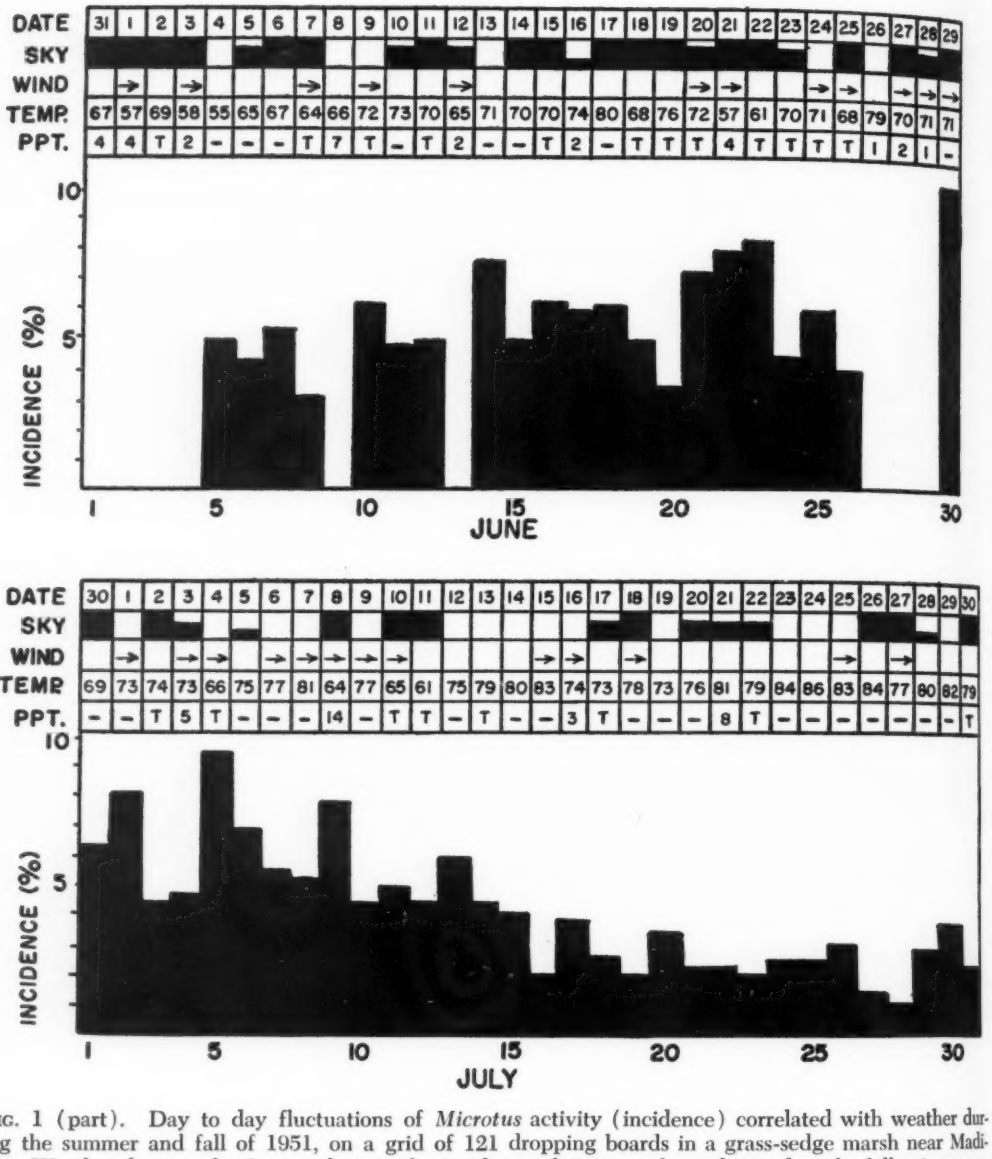


FIG. 1 (part). Day to day fluctuations of *Microtus* activity (incidence) correlated with weather during the summer and fall of 1951, on a grid of 121 dropping boards in a grass-sedge marsh near Madison. Weather data are for 6 P.M.; data on the incidence of visits are those obtained on the following morning. (Temperature in degrees Fahrenheit; precipitation in tenths of inches.)

Activity at the untreated boards also increased during the baiting periods, suggesting a general effect on the responsiveness of the animals, or, perhaps, a local movement of mice into the area. A carry-over effect was also apparent after bait had been removed. This effect may be seen in both odd and even series. It gradually subsided during early November (not shown in figure), but the incidence of use was still roughly twice that of the pre-baiting level at the termination of the test on November 20.

These and other similar observations indicate that baiting may be desirable for certain types of studies. It should be noted, however, that baiting introduces some undesirable biases for comparative studies of species abundance or population fluctua-

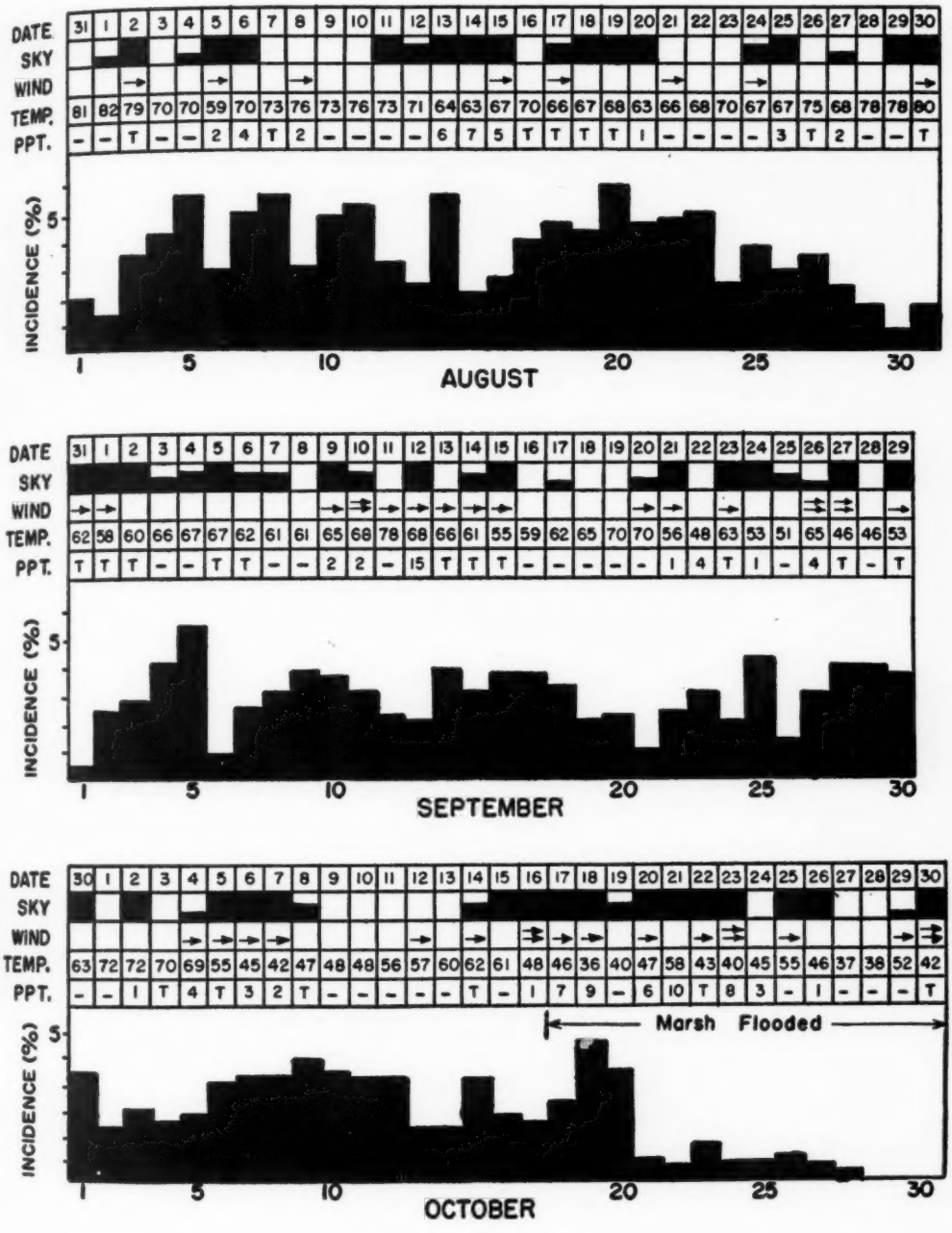


FIG. 1 (continued).

tions. No one substance has been found which is equally attractive to all small mammals, especially to groups with such divergent food habits as mice and shrews. A preliminary experiment on bait preference showed that while all three species encountered were recorded in considerable numbers with each of three bait types, *Sorex*

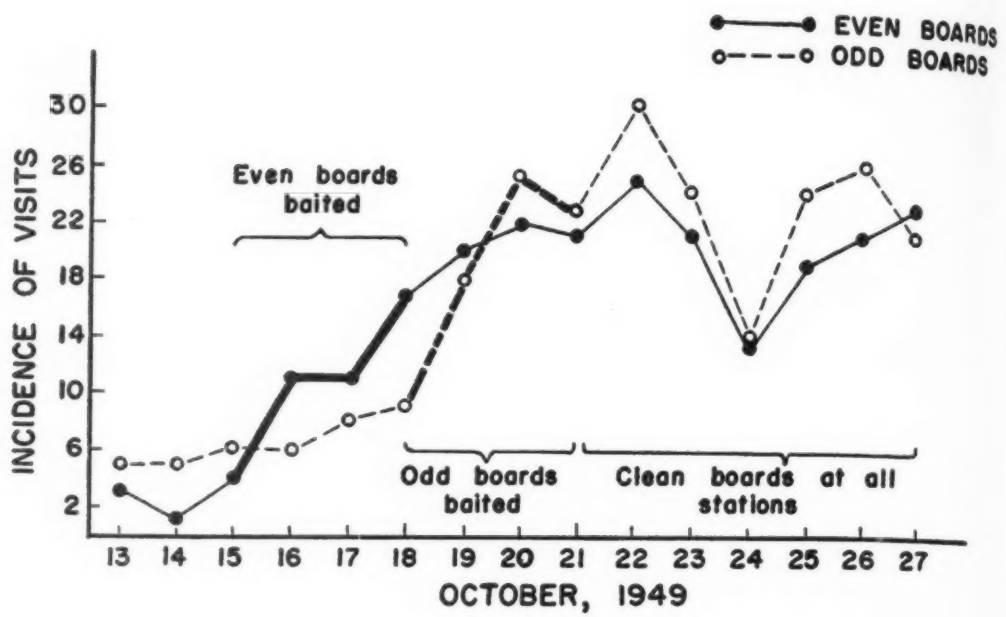


FIG. 2. Response of a *Microtus* population to the baiting of dropping boards with peanut butter.

and *Blarina* had a slight preference for peanut butter, and *Microtus* for rolled oats.

The bait preferences of any single species may, furthermore, change with the seasons, or geographically, in such a manner as to make comparisons dangerous. Another difficulty with baiting is presented by the attraction of insects and other invertebrates to baited boards. Such animals, as already noted, may interfere with survey procedures by destroying mammal droppings and by contaminating the boards.

For most studies where adequate data can be obtained without recourse to baiting, clean boards are preferable. Boards that have once been baited with any oily substance should never be considered unbaited since the residual effect is great and cannot be overlooked even after long periods.

Chemical lures, such as essential oils, scents, and urines, may have value in certain situations. A single test with anise oil gave positive results with *Sorex*, but no general increase in dropping-board use by other species. A test with *Microtus* urine gave positive results on a *Microtus* population: boards impregnated by leaving them for several days on the floor of a densely stocked enclosure were visited in the field 55 times in 131 exposures (41 per cent), while clean boards exposed concurrently in alternate positions were visited only 27 times in 135 exposures (20 per cent). Lures, like baits, should be used with caution until more is learned concerning their selectivity for particular species.

RECORDING THE RESULTS

Identification of droppings.—Fecal droppings and other signs of mammalian visitation cannot be as readily and accurately identified as trapped specimens, especially below the genus level. However, variations in shape, size, color, and content are often diagnostic (Webb, 1940) and were almost always adequate for separating the droppings of the four common species that visited the boards in our tests in southern Wisconsin. No satisfactory means were discovered for distinguishing the fecal pellets of *Peromyscus maniculatus* from those of *P. leucopus* or for infallibly detecting the occasional occurrence of rarer species. In all cases the identification of droppings and other signs will depend on a prior knowledge of the composition of the local fauna as determined by trapped specimens.

Problems of identification will obviously limit the applicability of the dropping-board technique to quantitative studies of dominant species until more refined methods of feces identification are developed. Reference collections of fecal pellets for study and comparison can readily be collected from live traps. Such specimens may be kept in dry form or in a preservative fluid.

Incidence (per cent of boards visited) vs. total counts (total number of droppings).—The number of droppings of each species was recorded for each board during these test runs. Counts on a board commonly varied from one to ten and occasionally ran up to 30 or 40 in a single night. These figures seemed to have some significance as indicators of the amount of activity at a station, but close observation revealed that numbers were by no means directly proportional to activity. Shrew droppings are often highly irregular in shape and may be variously fragmented according to the nature of the chitinous material incorporated. A *Microtus* may drop anywhere from one to ten complete pellets in a group. These clusters may adhere closely on a board and thus reveal their common origin, or they may become scattered and be indistinguishable from separately dropped pellets. Such irregularities in defecating habits, plus the chance of disturbance to accumulated droppings by new visitors, rendered the total count a poor index of total activity at any single station.

Incidence, or the per cent of boards that had at least one pellet or other sign of activity present as evidence of a mammalian visit, appeared to be a better criterion of population activity. Of course, a single board may sometimes be visited two or three times during a 24-hour period (Table 2). On boards where this seems to have occurred, a subjective evaluation of the amount of activity in terms of one, two, or three units may be made and used in the final tally of activity. Our experience, however, indicates that the straight incidence measure approaches the actual number of visits made to boards during an exposure period when this period is kept appropriately brief (see Table 2), and that a subjective evaluation of multiple visits at a few boards is generally unnecessary and undesirable. Where multiple visits occur commonly, it seems preferable to step up the servicing frequency rather than introduce a subjective factor into the incidence index.

INTERPRETATION AND EVALUATION

Explanation of dropping-board usage.—Since the surface area provided for defecating by dropping boards is insignificant (1/22,500 of the total area in a grid with 50-foot spacing), it is apparent that the animals must be attracted to the boards in some way. The one common characteristic of successful boards used in these trials seemed to be a reasonably smooth, flat and firm surface contrasting with the soft, irregular surfaces of the natural substrate. Natural situations, such as small flat-topped stones, cow chips, rain-packed mole hills, or smooth areas in well-worn runways, are used in the same way. It is possible that the animals seek out such objects or situations as defecating sites simply because they constitute desirable spots on which to pause during foraging activities. They may also possess special significance as "scent posts" as suggested by the increased attractiveness, already noted, of boards covered or impregnated with excreta.

Boards are frequently chewed along the edges, particularly during the winter season or after they have been in service for a long time. This attraction is believed to be of secondary importance, however, since metal and composition squares which do not possess the same chewing qualities gave comparable results.

An interesting confirmation of the hypothesis that smooth flat surfaces constitute the primary attracting feature of the boards was provided when settings in two heavily infested stubble fields failed to produce the expected results. Visual inspection of the fields revealed an abundance of *Microtus* sign, yet the boards with repeated exposure showed a usage incidence of less than one per cent. The abundance of droppings in the maze of runways, which were worn smooth and slick on the bare ground, suggested an excess of attractive defecating surfaces and a consequent loss of interest in the boards. A series of sample plots of one square meter each were accordingly laid out in these fields and in an undisturbed grassy field showing a 20 per cent usage of

TABLE 5. — EFFECT OF THE PRESENCE OF BARE SLICK EARTH UNDER STUBBLE ON THE USAGE OF DROPPING PLATFORMS BY *Microtus* IN THREE FIELDS

	Total Length of Runways Examined (Inches)	Per Cent of These Runways That Were Denuded	Visual Estimates of the Population	Per Cent Usage of Dropping Platforms
Grassy field	274	0	moderate	20
Grain stubble without ground cover	479	90.5	high	0.6
Stubble and clover and little ground cover	487	55.5	high	0.2

dropping boards. Measurements of the amount of bare slick earth in these plots gave a striking picture of the basic difference between these two superficially similar types of habitats (Table 5).

These observations incidentally reveal a possible limitation of the dropping-board technique in areas possessing smooth barren soil surfaces. No other instances of the phenomenon were encountered, however, in our studies.

Nature and evaluation of the index.— Figures obtained from records of usage of dropping boards are, of course, like records of trap success, merely indices of the population. As such their value is largely limited to comparative studies of interspecific, interseasonal, or interregional abundance. While a relative index may be as useful and as accurate as an absolute measurement for many types of work, it is desirable for evaluation purposes to compare the index directly with an absolute count whenever possible. Such counts are very difficult to obtain in nature and are usually further complicated by local movements of the animals to and from the censused area. Isolated populations provide an exception and an opportunity for intensive study. One such study was made of a natural *Microtus* population inhabiting a 0.55-acre island in a pond at the University of Wisconsin Arboretum. A complete tally of this population was made by exhaustive trapping and removal; dropping-board surveys were made before and after this removal. The results are summarized in Table 6, A. Before the removal, the 55 mice per acre (trap-removal figure) in this population were leaving droppings on 32 per cent of the boards each night; after the removal, there were, of course, no more droppings on the boards.

Since island populations constitute a rather specialized situation, attempts were made to get comparable information from noninsular areas. The procedure followed here was to decimate local populations by snap-trapping and compare the reduction in dropping-board usage with the number of animals removed. In the principal test (Table 6, B), 100 stations were set out at 25-foot intervals in a circuit in a grassy meadow heavily populated with *Microtus*, and the incidence of utilization recorded for 15 consecutive nights. The line was then divided into two portions, each having 50 stations and approximately equal activity, and one-half was trapped intensively with snap traps for three consecutive nights during which 54 mice were removed. The dropping-board index in the trapped portion of the line promptly dropped from 21.5 to 11.4 per cent, while in the untrapped portion it maintained its high, pretrapping level of approximately 20 per cent. Thus the 54 animals removed accounted for a reduction of about one-half in the incidence of usage of dropping boards in the experimental section of the line. Such figures of decrease in the dropping-board index are apparently functions of the actual population reduction and can therefore be used to compute such reductions. The relationship is not the simple arithmetical function that it might first appear to be, but is affected by geometrically decreasing values for both board use and trap vulnerability with increasing distances from the board and trap sites. The actual relationship depends on the adoption of a set of assumptions concerned with mobility which lies beyond the scope of this paper.

TABLE 6. — EFFECT OF REMOVAL OF A KNOWN NUMBER OF ANIMALS BY TRAPPING ON THE UTILIZATION OF DROPPING BOARDS

Test	Number Stations	Spacing in Feet	Species	Pre-trapping Incidence	Pre-trapping (Days)	Removed by Traps	Post-trapping Incidence	Post-trapping (Days)
A[1]	33	30	*Microtus*	32	(5)	30	0	(5)
B	50	25	*Microtus*	21.5	(15)	54	11.4	(5)
Control	50	25	*Microtus*	20.0	(15)	0	19.8	(5)
C	135	45	mixed	12.5	(4)	15	9.5	(2)
D	50	100	*Microtus*	10	(10)	19	9	(2)
			Peromyscus	28	(10)	15	15	(2)
			Sorex	45	(10)	2	46	(2)
			Blarina	7	(10)	14	9	(2)
E	50	100	*Microtus*	3	(3)	7	3	(3)
			Peromyscus	16	(3)	15	23	(3)
			Sorex	34	(3)	7	75	(3)
			Blarina	5	(3)	2	6	(3)
F	50	100	*Microtus*	10	(3)	15	13	(3)
			Peromyscus	25	(3)	11	16	(3)
			Sorex	34	(3)	2	47	(3)
			Blarina	5	(3)	11	10	(3)

[1] 0.55-acre island.

A smaller and less definite response occurred with trap removals of lower intensity. On one line with 45-foot spacing the removal of 15 animals decreased the visiting incidence from 12.5 to 9.5 per cent. In three tests on lines with 100-foot spacing, trap removals produced no regular reductions and even seemed to stimulate activity, especially in the shrews, possibly as a result of bait attraction.

Since snap trapping is widely used as a standard method of population sampling, it is interesting to compare results obtained by the two methods. Several tests were run in which traps and boards were alternated at successive stations along a line or otherwise exposed in close association for directly comparing their performance. The results are shown in Table 7. There was no significant difference in the sensitivity of the two devices for *Microtus* or *Blarina*, but boards were favored 2 to 1 by *Peromyscus* and better than 4 to 1 by *Sorex*.

Without information on absolute population sizes it is impossible to say which technique more accurately reflects the comparative status of the various species represented. Whether *Peromyscus* was only slightly more numerous than *Microtus* in the marsh tests, as indicated by the trap indices, or more than three times as numerous, as indicated by the boards, is unknown. The striking difference in the two indices for *Sorex* is thought, however, to reflect a lack of sensitivity of traps for this species. The seasonal cycle of abundance of shrews in this marsh, as indicated by trap-success figures over several years, shows a peak in winter and spring; this does not conform with the expected cycle of an animal with a spring breeding season. The dropping-board indices, on the other hand, show the expected summer and fall peak. Explanations of the peculiarities of the trap index are not available, but we consider this difference between the two methods to indicate that population levels of these shrews are more accurately reflected by dropping boards

TABLE 7. — COMPARISON OF RECORDS FROM DROPPING BOARDS AND SNAP TRAPS EXPOSED CONCURRENTLY ON TWO AREAS NEAR MADISON. FIGURES REPRESENT PERCENTAGE OF CAPTURES PER TRAP SET AND PERCENTAGE OF VISITS PER BOARD SET

	Marsh		Prairie	
Number of Exposures . . .	Traps 881	Boards 1,200	Traps 150	Boards 150
Microtus	5.7	4.0	11	11
Peromyscus	7.1	14.3	3	9
Sorex	8.5	37.0	0	0
Blarina	2.5	3.3	0	2

than by snap traps. This conclusion is supported by the observation that shrew droppings were often numerous on both sprung and unsprung traps particularly in fall and winter when three times as many traps had shrew droppings as captured shrews.

General considerations.—In addition to matters of accuracy as discussed above, consideration should be given to the practical advantages and limitations of the dropping-board technique in comparison with other quantitative survey methods.

The problem of differential selectivity of sampling devices is extremely difficult to evaluate and equally difficult to control. Traps that are efficient for one size or type of mammal are characteristically inefficient for others, and baits, as commonly used in trapping surveys, tend to extend and complicate this selectivity. Dropping boards undoubtedly are also selective for certain species or types, but, as noted above, our field records suggest that they are less so than traps. By avoiding baits and relying on the natural attraction of defecating platforms, we apparently have a relatively nonselective sampling device for small mammals in the size range of most mice and shrews. Further data are needed, however, to verify and amplify this conclusion.

The removal of animals in a snap-trapping program introduces a complication of unknown significance in long-range population studies. This difficulty may be reduced by limiting the take to a minimum sample or by the wide spacings of traps, but it is always present as a complicating variable. The difficulty may be avoided by using live traps, dropping boards, or direct-sign survey techniques. Of these, live trapping has many assets, but the expenditure of effort is great for these types of data, and there are definite limits to the frequency with which animals can be caught and handled without injury or disturbance. Dropping boards, although limited in the types of data they can provide, appear to offer the best opportunities for repeated sampling of a population without direct interference or disturbance.

The labor involved in accumulating simple population data is generally less for dropping boards than for either snap traps or live traps, but greater than for direct-sign surveys. Dropping boards are inexpensive and easy to make, easy to transport, and easy to service. A line of 100 boards can generally be set out in half the time required to distribute and set an equal number of snap traps; and servicing requires no more than a swipe with a brush or cloth. The amount of data obtained per run is, as we have seen, generally greater than with traps. Under average conditions in late fall 20 to 30 per cent of the dropping boards were visited each night, and usage as high as 90 per cent was occasionally recorded. A single board may also be visited by 2, 3, or even 4 species in a single night, and evidence of repeated visits to the stations is generally retained.

The still greater simplicity and speed of the direct-sign survey has much to be said for it. These advantages are balanced, however, by considerations of the difficulty of distinguishing fresh from old signs and of detecting at all the presence of dark-colored and relatively amorphous shrew droppings, especially on dark or moss-covered soils. There is also, inevitably, a considerable variation in the skill of workers in detecting and evaluating signs.

APPLICATIONS

Preliminary observations and tests have been made of several applications of the dropping-board technique. These are briefly summarized below.

Studies of population trends and fluctuations.—The usefulness of dropping boards in obtaining a continuous record of population fluctuations has been discussed in the previous section of this paper, and an example of the employment of the technique to a population of *Microtus pennsylvanicus* is presented in Fig. 1. Limitations of this application have not been thoroughly explored, but dropping boards seem to provide an approach to the elusive problem of week-to-week changes in population density.

Studies of local distribution.—While the occurrence of a species in an area should be determined by actual specimens of the animal, it is believed that the quantitative aspects of local distribution and of habitat relationships within the known range could in many cases profitably employ the dropping-board technique. A map showing the January, 1950 distribution of *Microtus penn-*

sylvanicus in a 60-acre field at Madison, as determined by a grid of dropping boards, is shown in Fig. 3. Detailed analyses of the vegetation and soils in such a mapped field could provide much valuable information on ecological factors affecting distribution. A series of similar maps prepared at regular intervals throughout the year might reveal some interesting facts about population movements.

Studies of species associations.—Data on the coexistence and degree of association of sympatric species carry increasing importance in modern studies of interspecific relationships. Dropping boards would seem to provide a useful tool for such studies, since each board is capable of preserving the record of a series of visitors during a single exposure period. As many as four different species have been recorded at a single station in one night. Statistical analyses of interspecific association using the methods of Dice (1945) or Cole (1949) should be readily derived from dropping-board data.

Activity rhythms.—Diurnal, lunar, and other activity rhythms in small mammals have been studied primarily under artificial conditions. Dropping boards may offer some help in solving the difficult problem of activity measurements in natural environments. As a test of this application, a line of 100 boards was set out 50 miles south of Madison on October 28, 1950, and serviced every two hours for 48 hours. Another similar line was set out in a *Microtus* meadow near Madison on November 7, 1949 and serviced every three hours for 72 hours. The results of these preliminary tests illustrate the applicability of the dropping-board technique for measurements of activity rhythms (Fig. 4).

Measuring the effects of weather and environmental conditions on activity.—Dropping boards may be used, as are traps, in correlating small-mammal activity with weather conditions or with various disturbances and alterations of the habitat (Fig. 1). The possibility of obtaining a continuous record at one site without disturbing the animals makes dropping boards particularly useful for such studies. It should be noted, however, that a hard rain may obliterate the record on the boards, and flood or sleet storms may make it impossible to operate a line. Boards were frozen in and unusable for as long as three consecutive weeks during some of our studies.

Studies of movements.—A special application of the dropping-board technique is the measurement of foraging range by collecting the distinctive droppings of "tagged" animals. Details of the daily wanderings of a single meadow mouse were traced in one study by live-trapping and "tagging" an animal with radioactive phosphorus (P_{32}) and then, during the following week or two, scanning a grid of aluminum boards surrounding the trap-release site for radioactive droppings and urine (Miller, 1957).

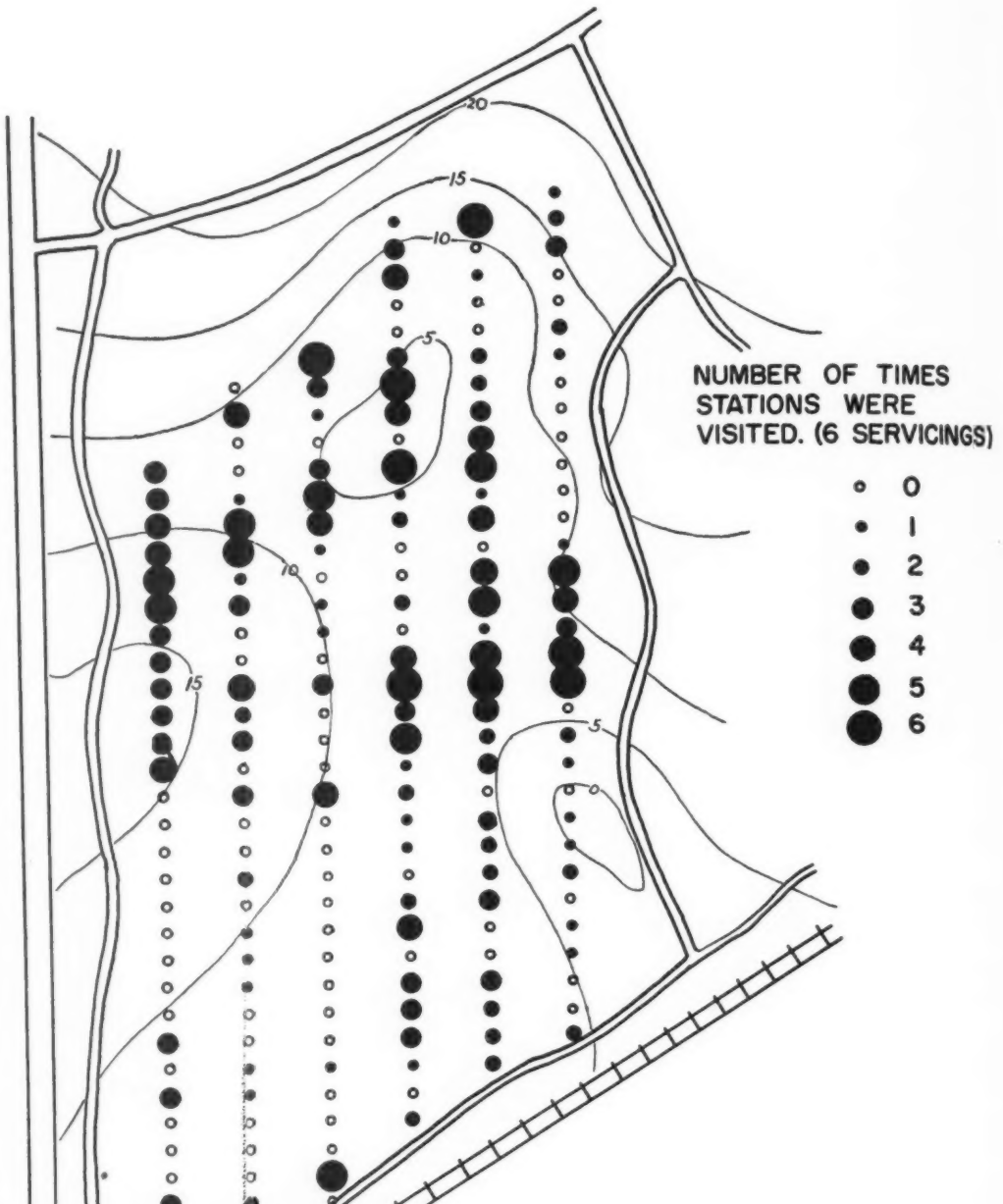
In preliminary tests it was found that mice and shrews will accept baits colored with methylene blue and later deposit blue droppings on nearby boards. By an appropriate spacing of color-bait stations along a line of dropping boards, a good picture of the extent of average and extreme foraging excursions can be obtained for various species.

Evaluating repellents and lures.—Tests for the effectiveness of anise oil and *Microtus* urine as lures on dropping boards have already been described. A similar test with kerosene as a purported insect and slug

TABLE 8.—REPELLENT QUALITIES OF KEROSENE ON A LINE OF 150 PLYWOOD DROPPING BOARDS[1] AT MADISON, OCTOBER 1952

	Incidence of Visits (Per Cent)					
Day	3	6	9	12	15	18
Treated with kerosene	0	0	0	0	0	4
Untreated controls	19	16	19	20	20	16

[1] Alternate boards were treated after nine days of preliminary exposure. The positions of treated and untreated boards were switched on the ninth day.


20
15
10
5
10
15
5
0
NUMBER OF TIMES
STATIONS WERE
VISITED. (6 SERVICINGS)
0
1
2
3
4
5
6

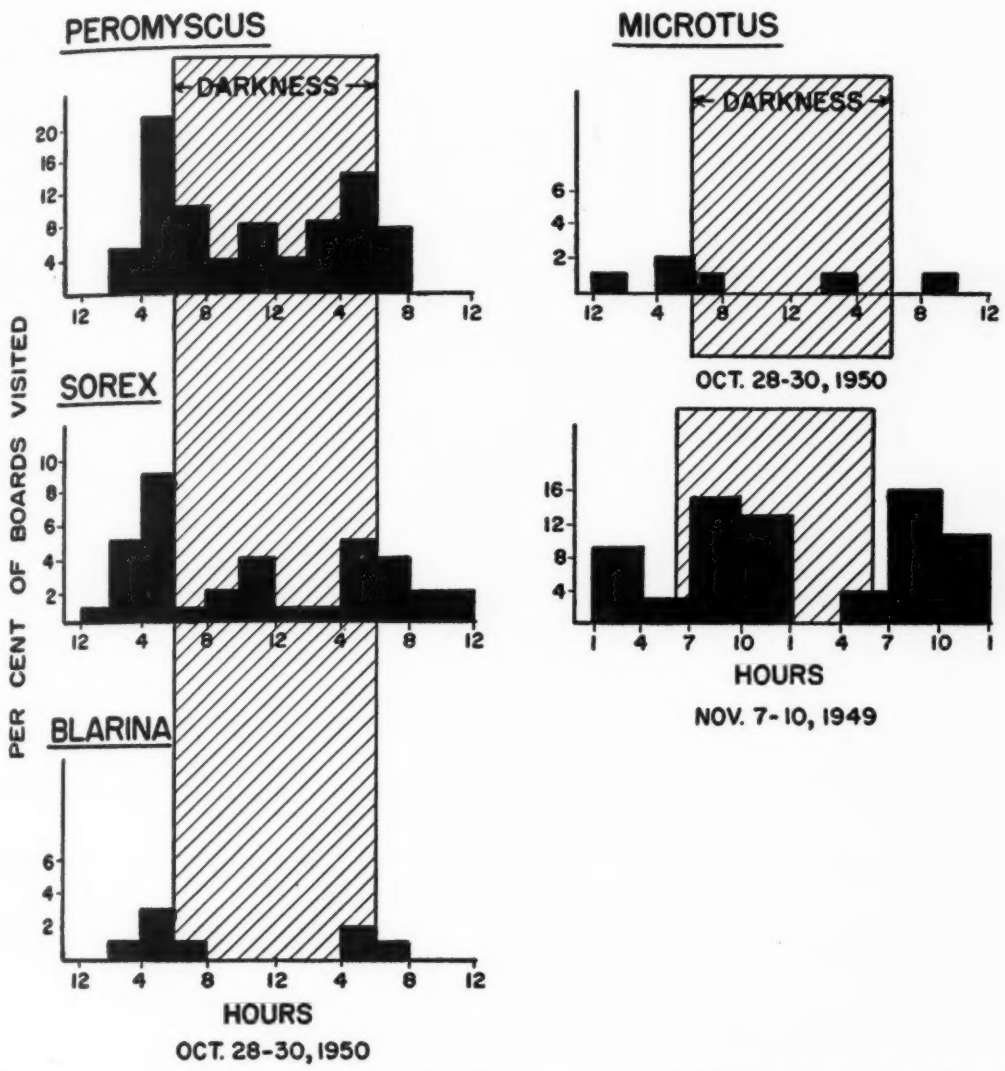


FIG. 4. Day–night fluctuations of activity of small mammals as revealed by dropping boards serviced at 2- and 3-hour intervals.

repellent (to prevent coprophagy on the boards) demonstrated a strong repellent quality of this material for mice and shrews (Table 8). Dropping boards should prove useful in field tests of various pest repellents.

Studies of food habits.—The original use to which dropping stations were put (Eadie, *op. cit.*) was the collection of droppings of *Blarina brevicauda* for analysis of their content. Fecal material collected from dropping boards was used in one study of seasonal changes in the food habits of shrews in a marsh near Madison. Materials so collected provide opportunities for analysis of geographic and ecological as well as seasonal variations in food habits. They may also prove useful in studies of the distribution of endoparasites of small mammals.

FIG. 3. Distribution of *Microtus* in an abandoned field as determined by a grid of dropping boards.

SUMMARY

Small squares of wood, metal, or composition board set out in the field as defecating stations were found to provide a means of measuring populations of small mammals which was less selective, less disturbing, and more efficient than the usual trapping techniques and more precise and objective than direct-sign surveys. Smooth, neutrally colored, hard-surfaced boards, 4 inches × 4 inches in size, proved to be most satisfactory, and weather-proofed, ¼-inch plywood was adopted as the standard material for the preliminary tests here described. Baiting of boards was not necessary for good results and was avoided in general tests as being differentially selective for certain species. The distance between boards in a line or grid, when greater than 25 feet, had little effect on the percentage visited. Lines were generally serviced every 1, 2, or 3 days depending on the amount of small-mammal activity and the amount of extraneous disturbance.

Identification of the fecal droppings of dominant species as to genus was quite simple in the area covered by this study and should be generally feasible where prior information on the composition of the local fauna is based on trapped specimens. The presence of droppings or other sign on the boards may be recorded as an incidence index (per cent of boards visited) or as a count of droppings deposited; the former appears to be preferable and satisfactory for most work, but a combination of the two methods may be desirable at times.

Incidence indices on a large number of lines and grids run in a variety of situations in southern Wisconsin between 1949 and 1955 varied from 0 to 90 per cent and averaged around 20 per cent. Direct comparisons with snap-trap indices showed a higher incidence of visits at dropping boards for three of the four common local species (*Peromyscus leucopus, Blarina brevicauda,* and *Sorex cinereus*) and a slightly lower incidence for one (*Microtus pennsylvanicus*). Indirect evidence suggests that the dropping-board index was more accurate than the snap-trap index in demonstrating the seasonal cycle of abundance of *Sorex* and possibly of the other species.

Evaluation of the dropping-board index in terms of absolute population was made on a small island by removing and tallying the entire population after an initial survey, and on the mainland by decimating populations with snap traps and comparing the ensuing decrease in the index with the measured population reduction. The 55 mice per acre on the island before removal produced a 32 per cent incidence index. In the principal controlled decimation experiment, a removal of 54 animals along ¼ mile of line depressed the incidence index from 21 per cent to 11 per cent.

Evidence is presented which suggests that the use of dropping boards by small mammals is related to the animals' selection of smooth bare surfaces for defecating. Also there is possible social significance of defecating and urinating sites as "signal posts."

Preliminary observations and tests suggest that the dropping-board technique may prove to be useful in studies of population fluctuations, ecological distribution, species associations, activity rhythms, environmental responses, local movements, the effectiveness of lures and repellents, and food habits.

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AN ANALYSIS OF COVARIANCE OF COTTONTAIL RABBIT POPULATION DATA[1]

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Many studies of upland game populations require an estimate of a population total or some suitable index to population density. The estimation of these statistics has been accomplished by various methods, e.g., a tag-recapture or flushing-count procedure. Fundamental to all such estimation procedures is the definition of the population in question and the establishment of the proper sampling and analytical methods required to satisfy the needs of the researcher.

This paper is concerned primarily with describing an analytical procedure, namely the analysis of covariance, as applied to population data of the cottontail rabbit (*Sylvilagus floridanus*) collected in Cumberland County, Virginia, from September, 1953 through January, 1954.

These data are a small portion of a study reported upon by Byrd (1956). The objectives of the complete study as stated by Byrd (*op. cit.*) were ". . . to determine the trend of natural plant succession on abandoned fields in a representative county of the Virginia Piedmont and to attempt to interpret this information in terms of practical wildlife management." He defined abandoned land as ". . . cropland which is no longer being cultivated and on which there has been no major disturbance (either by man, by livestock, or by other causes) since the time of last cultivation."

Methods

Sampling. One of the game animals of concern to Byrd was the cottontail rabbit. It was of interest to know which of the four defined age groups of abandoned fields was most heavily utilized by the cottontail rabbit during the period of Byrd's (1956) study. The age groups were called "successional classes" and contained the following abandoned fields:

Succession Class I, one-year-old fields;
Succession Class II, 2–4-year-old fields;
Succession Class III, 5–10-year-old fields;
Succession Class IV, 11–25-year-old fields.

These classes were selected as it appeared that there was, for all practical purposes, a noticeable difference between the floristic composition of these age groups. The floristic composition of these successional classes has been discussed in detail by Byrd (*op. cit.*).

Thus, the populations of interest were four in number and consisted of all defined abandoned fields in each of the four successional classes, or more specifically, the rabbit populations utilizing each of these successional classes during the period of study in Cumberland County. However since the fields studied were not selected at random from the populations of interest, the biological conclusions in this paper may be invalid. Cumberland County is in the approximate center of Virginia and, on the basis of Production and Marketing Administration records, was believed to have approximately 6.7 per cent (12,306 acres) of its land area in abandoned land (*ibid.*).

The study fields were selected subjectively, as the junior author did not believe the study permitted the use of random sampling procedures (*ibid.*). Sampling by such a procedure is open to criticism, as bias can easily be introduced into the sample. Byrd (*ibid.*) states, "Abandoned fields were first located by use of aerial photographs. Once a field was located on a photograph, it was inspected on the ground and its ownership, treatment, and age of abandonment established, where possible. A total of 172 abandoned cropland fields was inspected, of which sufficient historical data were obtained [by personal interview] on 65 fields to permit their use in the detailed plant and animal studies."

Rabbit flushing lines were established on 20 fields, 5 in each of the 4 successional

[1] Release No. 57-3, Virginia Cooperative Wildlife Research Unit.

classes. In these 20 fields permanent parallel lines, 15 feet apart, were walked each month and the number of rabbits flushed was recorded from September, 1953 through January, 1954. The initial line was established 15 feet in from any boundary. No attempt was made to establish randomly the location of the initial line, for the starting point was considered to be unimportant as the complete field was traversed. It is recommended that, in future studies, consideration be given to the random selection of the starting position and to the approximate distance between lines. Intuitively it seems that the characteristics of the herbaceous cover should have an effect upon the flushing distance. Perhaps the distance between lines should be limited to such an extent that there is little doubt that nearly all rabbits in the field will be flushed. The order of walking the 20 lines each month was determined from a table of random numbers, with observations being completed as near the first of the month as possible. An attempt was made to standardize direction of travel, time, and weather conditions during the observation period.

Utilization of flushing-line observations has the decided advantage of being related to the population of interest to the hunter, and consequently the game manager, i.e., the population available to the gun of a hunter who hunts without a dog. Data collected in the complete study are presented by Byrd (1954).

Analysis. As the flushing lines varied in length, it was necessary to select an analytical procedure that would take this variability into account. The analysis of covariance appeared to be an appropriate method to utilize where the length of line was considered the covariate. If the flushing lines had been of equal length, the analysis of variance would have been suitable. The analysis of covariance permits an interpretation of how much of the difference in results is attributable to the length of flushing line. Workers in the wildlife profession have a tendency to adjust for length of line by transforming the counts to counts per uniform length of line. Such a procedure does not utilize all the information available in the data and can be misleading, e.g., zero counts are considered as zero counts per uniform length of line regardless of the length of the flushing line, obviously an incorrect procedure. It is acknowledged that such a transformation may be suitable in some studies.

Further, the statistical analysis consists of an analysis of covariance for a partially hierarchal model, as described for an analysis of variance by Harter and Lum (1955). Although their discussion is concerned with an analysis of variance, a model containing a covariate can be utilized simply by applying the analysis of covariance procedure discussed by Snedecor (1946). The model states that the number of flushed rabbits (y_{ijk}) on the k^{th} line ($k = 1, 2, \ldots, 5$) during the i^{th} month ($i = 1, 2, \ldots, 5$) in the j^{th} successional class ($j = 1, 2, \ldots, 4$) is expressable as a linear function of the grand mean (μ), fixed month effect (α_i), fixed successional class effect (γ_j), random field (or line) effect (c_{jk}), the month $\times$ class interaction ($\alpha\gamma_{ij}$), and the effect of the covariate $\beta(x_{jk} - \bar{x})$, where x_{jk} is the length of the k^{th} line in the j^{th} successional class. It was assumed that the residual errors (e_{ijk}) were normally and independently distributed around zero with constant variance. The model is written as $y_{ijk} = \mu + \alpha_i + \gamma_j + c_{jk} + \alpha\gamma_{ij} + \beta(x_{jk} - \bar{x}) + e_{ijk}$.

It is sometimes necessary to apply a transformation to raw data in order to satisfy various assumptions in a specific statistical analysis. Hartley, *et al.* (1955) used a logarithmic transformation on pheasant roadcount data and discussed the appropriateness of such a transformation when there is a linear relation between the standard deviation, σ_y, and the mean μ_y, of the form $\sigma_y = a + b\mu_y$. Following the suggestion of these writers, Schultz and Muncy (1957) have applied a similar transformation to deer counts on walking observation lines.

With regard to the rabbit flushing data being discussed in this paper, there was no relationship of this type discernible. There was, however, a very slight indication that the monthly population means and variances might be approximately equal, indicating that a square-root transformation would be appropriate. Primarily on the basis of a comment by Bartlett (1947), the transformation $\sqrt{(y_{ijk} + 0.5)}$ was used with the unmodified covariate, x_{jk}, in the analysis of covariance. Bartlett (*ibid.*) stated that,

"When statistical data consist of integers, i.e., whole numbers, such as number of bacterial colonies in a plate count, or number of plants in a given area, homogeneous conditions will often lead to variation in these numbers x following the Poisson distribution.... I recommended [in a previous paper] the use of $\sqrt{(x + \frac{1}{2})}$ in place of $\sqrt{x}$ when very small numbers were involved (e.g., means in the range 10 to 2, especially when zeros are occurring among the observed numbers)...." Federer (1955) comments that, "The square root transformation is useful for data following the Poisson distribution. Counts of events having a small probability of occurrence often follow this distribution." The selection of an appropriate transformation is often difficult, as a transformation that results in satisfying one assumption does not insure that satisfactory relationships in the original variate are not disturbed. Fortunately, failure to satisfy certain assumptions often may not be serious. As the square-root transformation is used to alter heterogeneity of error variance, the consequences of heterogeneity in an analysis of the original data are of concern. Cochran (1947) has stated that, "If ordinary analysis of variance methods are used when the true error variance differs from one observation to another, there will as a rule be a loss of efficiency in the estimates of treatment effects. Similarly, there will be a loss of sensitivity in tests of significance. If the changes in the error variance are large, these losses may be substantial. The validity of the F-tests for all treatments is probably least affected. Since, however, some treatment comparisons may have much smaller errors than others, t-tests from a pooled error may give a serious distortion of the significance levels."

RESULTS

Main effects. The results of the analysis of covariance showed no statistically significant difference between the adjusted averages for months (Table 1). This could possibly be explained as only a limited reduction in the population due to hunting or other environmental factors during the study period. A substantial reduction in the population that was obscured by various factors could have occurred, e.g., an influx of individuals adjusting to habitat changes or the flushability of an individual increasing due to environmental changes within the study field. We should not neglect to recall that, even though a substantial difference in monthly averages may have occurred, the variability inherent in the study method and the subjective sampling procedure may preclude detection of these differences by the statistical procedure and sample size utilized. There is an indication in the monthly data presented by Byrd (1956), in terms of "rabbits per 1,000 feet of line," that a slight decrease in the number of rabbits counted occurred through the study period. As population reduction is the biologically acceptable norm, we can only conclude that the sampling design was incapable of establishing statistically significant differences of this magnitude. The total number of rabbits counted on all lines during September through January was 19, 19, 14, 14, and 13, respectively. Such a minor change in counts could have little

TABLE 1.—ANALYSIS OF COVARIANCE AND TEST OF SIGNIFICANCE OF ADJUSTED MEANS OF RABBIT FLUSHING-LINE DATA

Source of Variation	Degrees of Freedom	Sums of Squares and Products			Errors of Estimate			
		$\Sigma(y-\bar{y})^2$	$\Sigma(x-\bar{x})(y-\bar{y})$	$\Sigma(x-\bar{x})^2$	Sum of Squares	Degrees of Freedom	Mean Square	F-ratio
Total	99	15.9071	41,987.28	1,799,104,116	14.9272	98	—	—
Months	4	0.3254	0	0	0.3254	4	0.0814	1.00
Classes	3	6.1383	28,909.74	994,107,758	5.3708	3	1.7903	8.39**
Lines within Classes	16	3.4131	13,077.54	804,996,358	3.2007	15	0.2134	—
Month × Class	12	0.8082	0	0	0.8082	12	0.0674	0.83
Error	64	5.2221	0	0	5.2221	64	0.0816	—

** Indicates significance at the 1 per cent level.

practical management significance.

A comparison of successional classes showed a very statistically significant difference between classes (Table 1). This is assuring as, based on intuition as well as observation, wildlife managers and hunters believe that different habitats support different population densities. It should be recalled that a subjective sampling procedure was utilized. Consequently all biological conclusions may be invalid. The adjusted transformed means for successional classes I through IV are 1.0363, 1.4468, 0.9454, and 0.8250, respectively. A comparison of classes on an individual basis showed a statistically significant difference only between successional classes I and II, II and III, and II and IV. They were significantly different at the 5, 0.1 and 0.1 per cent level of significance, respectively.

It is of interest to note that an adjustment for length of line, as applied in this analysis of covariance, had little effect on increasing the precision in the study (Table 1), even though lines varied in length from 1,242 to 15,380 feet.

A test of the hypothesis that the pooled regression coefficient is not significantly different from zero should be of interest to the investigator who wishes to determine if it is worthwhile to introduce the independent variate, length of line, in the analysis. Our regression coefficient was not significantly different from zero as the computed F based on 1 and 15 degrees of freedom was 1.00. An investigator obtaining such a result prior to applying an analysis of covariance would decide that there would be little advantage in adjusting for length of census line by means of an analysis of covariance; however, as this paper is concerned with the complete analysis rather than actual results of this study, we have applied the complete analysis of covariance. In a further inspection of such data, we might be interested in comparing the individual regression coefficients for each successional class by month to justify a pooling procedure as utilized in this paper. Snedecor (1946, section 12.5) has described the appropriate procedure to follow in such a comparison. The individual regression coefficients may possibly give an indication as to the "flushability differences" between different vegetational types or time periods.

Interactions. The month × class interaction was not significantly different from zero (Table 1). This implies that month-to-month changes in the average transformed counts were not significantly different for the different successional classes.

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CONCLUSIONS

An application of an analysis of covariance to the study of a game population has been presented. Where flushing lines of unequal length are utilized to study relative population densities, it appears that an analysis of covariance is a proper analytical procedure. The flushing-line method of comparing populations on a relative basis may be especially desirable where the populations of direct interest to the hunter are being studied. The desirability of utilizing acceptable sampling and analytical procedures cannot be overemphasized if reliable conclusions are to be drawn.

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OUR GROWING NEED: A PLACE TO PRODUCE AND HARVEST WILDLIFE[1]

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It has become trite to say that one of the wildlife administrator's toughest problems is to provide an increasing number of hunters a place to pursue their sport. Yet, this remains a most critical and urgent problem, and promises to get much worse. The problem involves all game species, but the needs are most urgent for waterfowl and upland game.

The difficulties of maintaining places to produce and places to harvest game, while often considered separately, are but phases of a single problem. To solve one properly is to solve both.

The destruction of production habitat is alarming! In addition, it becomes more difficult each year for the sportsmen to find a place to hunt once a surplus is produced. Drainage, modern farming practices, industrial and residential expansion, and power and flood-control projects steadily decrease production habitat, while hunters find much of the remaining land posted or open to hunting only through the payment of unreasonable fees.

The problem is, to a large extent, the outgrowth of population and economic pressures. We are awed by the phenomenal increase in hunting-license sales during the past 15 years. But, at the present rate of growth, population experts are predicting that the United States population will increase to over 225,000,000 by 1975 (Zitter, 1955). By the year 2000 we may well reach the 300,000,000 mark—almost twice the present population. Nor is this a long look into the future: 1975 is only 19 years away —less time than many of us will put in before we can "retire from this problem." The year 2000 is no longer a nebulous figure from the writings of H. G. Wells, but only 44 years away—a time many of us will see. The significance of these projected population figures escapes unless translated into terms of pressure per square mile. For example, Michigan has 20 hunting-license buyers per square mile of total area; Ohio, 15; Wisconsin, 10; and Illinois, 9. What will these pressures be in 1975? In 2000?

Obviously, the increasing world and United States population will place additional demands on natural resources. At the same time, automation and other advances will allow more leisure time, more time for more people to fish and hunt. In the face of these pressures, the administrator must attempt to produce wildlife in harvestable numbers, and make it available to the sportsmen.

Generally speaking, most game, but particularly upland game and waterfowl, must be produced and harvested on private land. In Illinois for example, 98 per cent of the land is in private ownership; 97 per cent in Ohio; 85 per cent in Wisconsin; and 79 per cent in Michigan. It is obvious that the solution to public-hunting problems must be found on private lands.

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While there are still great gaps in our technical knowledge, wildlife management has now arrived at the point where technical skills outstrip our ability to put these skills to use on the land. We find ourselves in the paradoxical position of knowing how to produce a highly prized commodity without being able to "market" it.

If hunting is to continue as we know it, even for a relatively brief period, ways of maintaining production habitat and harvest opportunities must be found.

ATTEMPTS TO HANDLE MOUNTING HUNTING PRESSURE

This is not a newly discovered or expressed problem, and many varied management efforts are being used to accommodate mounting hunting pressures.

Land acquisition is an important phase of almost all wildlife-management programs, and much progress has been made in acquiring key areas designed to meet specific needs. While acquisition is an important tool and relieves a portion of the pressure, it is quite obvious, for example, that Michigan cannot acquire enough land to handle 1,200,000 hunters. To accommodate such numbers would require the full utilization of every possible acre.

Much money has also been spent on public relations—trying to improve farmer-sportsmen relations. But this approach does not get to the crux of the problem, and more and more land is lost to game production and public use.

A wide variety of habitat-improvement programs have attempted to interest the farmer by making plantings useful to the landowner and, at the same time, beneficial to game. This too, is but a stopgap measure. Most plantings are designed to meet only minimum habitat requirements. Even if these are presumed to be effective, progress is infinitesimal when habitat preservation or restoration is compared with the alarming rate of habitat destruction. We must painfully admit that this, too, is a losing battle.

Commercial hunting areas are increasing. These relieve some of the pressure and have a definite place in the over-all scheme. But, for the same reasons that face the states, commercial clubs cannot provide enough hunting for the general public.

There have been many surveys, the most recent sponsored by the U.S. Fish and Wildlife Service (1956), to determine the economic impact of money spent for fishing and hunting. The results are indeed impressive. It can be safely said that hunting is a bigger business than many industries, and in some areas actually results in larger expenditures than farming. But these national statistics do little to convince Farmer Jones that a fence row is worth more than a row of corn, or that there is more money in his pocket because his land produced four broods of pheasants.

There have been some attempts, discussed later, to compensate the landowner for game produced and with surprisingly successful local results.

These various approaches, each of individual value, have collectively done little more than "skirt around" the problem.

What has not been attempted is a concerted effort to develop an economic system, supported by guiding legislation, to give a fair return to the landowner—in plain and simple words, to pay the landowner for game as a crop, and for the privilege of harvesting that crop.

THESIS

It is the thesis of this paper that the solution to the problem of maintaining production habitat and harvest opportunities on a major portion of this nation's lands lies in developing a system of payment to the landowner, and that such payment will guarantee the maintenance of both adequate habitat and harvest opportunity. It is proposed that the responsibility for developing and launching such a system rests with the wildlife agencies.

THE PHILOSOPHIC BASIS FOR PAYMENT

Such thinking is often considered to be "un-American." It seems to violate our heritage and concept of hunting in the free American tradition. A review of legislative and economic philosophies, however, does not support such criticism.

Payment to the landowner does not violate the legal concept of the common ownership of game, as reviewed by Judge F. D. Phillips (1956) of Richmond County, North Carolina. The power of control rests with the state, as a trust for the benefit of the people. However, "When the state has an owner-

ship of wild game within its borders, the individual owner of real estate has an interest in the game on his premises. This interest is not an absolute property right, but is in the nature of a qualified property interest in such game. No other person has a right upon his premises, without permission, to take game. Subject to the regulations imposed by the state, the owner of the land has the right to control the game on his lands." Thus, payment to the landowner accepts another old American tradition—absolute respect for land ownership.

Is it so un-American to pay for value received? Is this not the very basis of our economy? From an economic standpoint, there is every justification for paying the landowner to produce game and for the privilege of harvest. The "National Survey of Fishing and Hunting" (U.S. Fish and Wildlife Service, 1956) showed that over 11,000,000 people hunted in 1955, and spent roughly $1,000,000,000. This places hunting in a class with many big businesses. Compare, for example, the $1,000,000,000 spent on hunting and fishing with the estimated $1,700,000,000 spent for all spectator amusements, such as movies, theater, concerts, and sports (Patton, 1956). This survey (*ibid.*) further points out that the expenditures go to a wide variety of businesses. Of the $494,000,000 spent by small-game hunters, $232,000,000 was spent for various types of equipment, $16,600,000 for food, $3,900,000 for lodging, $50,100,000 for transportation, and so on. But it is significant that only $299,000, or six-hundredths of one per cent, is clearly identified as having been spent for leases or privileges. While more than this amount no doubt reached the landowner, the fact remains that he is the recipient of a very minor share of the great amount spent on hunting—a small partner when the proceeds are passed out.

This same point is borne out in a recent Pennsylvania survey on deer economics (Pasto and Thomas, 1955). Of the $1,400,000 spent by deer hunters in two counties, farmers received only 3 per cent. In attracting this business, the landowners sustained a loss of $195,300 through deer and hunter damages. Thus, the result was a net loss to the landowner while supporting a business in which others showed a gain!

It is abundantly clear that hunting is a big business, one that affects the economy of the entire nation. It is equally evident that the landowner, whose role is all-important, is not receiving an equitable share in the business he sustains. It should be equally clear that it is poor business not to protect the investment, or, in wildlife parlance, assure a "sustained yield." We must recognize also that wildlife is in economic competition with agriculture and other interests for use of the land.

In this country, we know that any commodity can be produced in any amount, if we are but willing to pay for it. Indeed, it can be produced in surplus; we need only to create the market to find many willing producers. This is true of tanks, planes, autos, wheat, and corn; it is also true for pheasants and waterfowl.

Examples of the Payment Principle

The need for compensating the landowner has long been recognized but actually carried out only in isolated cases. That it can be accomplished on a broader scale is evident.

One of the more notable examples is Texas. For almost 30 years, under statutory recognition, privately owned lands of Texas have been operated as shooting preserves to which the public has been admitted as paying guests. In 1943 (Hahn, 1945) the net income from hunting leases totaled well over $1,000,000 in Gillespie County alone. Several ranchers valued the deer crop on their land almost as much as the livestock. As high as $200 was paid by a single hunter for the season. The average for fairly good hunting areas was about $30 per person. The presence of game is reflected in land prices. While the Texas situation may not be ideal for other areas and the fees may be considered high, this arrangement illustrates the value of payment to the landowner.

Michigan's Williamston Plan (Stuewer, 1953) is a splendid example of a landowner-sportsman relationship, without benefit of payment to the landowner.

Ohio tried a program of purchasing or leasing nesting cover on agricultural lands, but this proved too costly and required high administrative and maintenance costs.

California (Anon., 1954) now operates a system of cooperative shooting grounds con-

sisting of about 185,000 acres, which will accommodate 20,000 hunters a day. Most of these are available to the hunter at no cost except where local sponsoring groups are charging fees to raise funds for civic improvement.

Wyoming has a tag attached to the antelope permit which, when turned over to the owner on whose land the animal is killed, can be redeemed for cash when turned in to the state.

Florida purchases key tracts and leases the hunting privilege on large blocks around these for management and public-hunting purposes. Most are open for a "season ticket" fee of $5.00. Approximately 3,700,000 acres have been opened to public hunting under this system (Anon., 1955).

Utah has a "pheasant unit" program whereby landowners, collectively holding 1,000 contiguous acres, can join together and charge a nominal fee for the hunting of pheasants. This plan is covered by legislation and provides state cooperation. Ohio attempted a similar program and still has authorizing legislation, but it was probably initiated "before its time."

For many years, Wisconsin has maintained a system of leasing the hunting privileges on large blocks of land, some of these adjacent to management areas. This system, too, has met with considerable success.

These are but a few of the varied efforts that have been made to secure public hunting on private lands through cooperation or some form of landowner payment. These have not attempted, however, to keep all of the lands open—only selected blocks.

THE ALTERNATIVES

Supposing we let "nature take her course," so to speak. The pattern is clear: more habitat destruction, more closed lands, increased commercial shooting areas, and the evolution of the European system which accommodates only the few; or, protective legislation, sponsored by the landowners or commercial interests, not wholly acceptable to the wildlife agencies and economically prohibitive to the general public.

If the wildlife agencies fail to take the initiative, two dangers are apparent: (1) the loss of additional production and harvest habitat; and (2) the very real possibility of undesirable legislation. The question is simply this: Are we content to accept the inevitable, or take an active, aggressive role in determining what the future shall be?

CONCLUSION

—It is the responsibility of the wildlife-management agencies to produce harvestable surpluses of game, and for making these surpluses available to every segment of the American public. If this is to be achieved in the face of an expanding population and increased demands upon our resources, a major portion of the private lands must be utilized for production, and remain open to public hunting. The best means of achieving this goal on private lands is through a system of equitable payment to the landowner.

It is not enough just to recognize the need, or to point out that some specific plan is impractical. That is defeatist. It is the responsibility of the wildlife agencies to take the initiative in developing such a plan.

THE PROPOSAL

On what basis should payment be made to the landowner? On the number of acres of suitable habitat maintained, the number of game animals harvested, or the number of hunters accommodated? Should payment be made directly by the sportsmen, or through the state?

It is not the intent of this paper to suggest a specific system. The problem is too large and too complex for one worker or one agency to solve. Further, it is not exclusively a wildlife problem, but involves agricultural interests, sportsmen, legislators, and wildlife agencies.

Rather, it is the purpose of this paper to suggest a plan, as the preliminary step for developing a system of compensating the landowner for the purpose of keeping virtually all land productive of wildlife and open to hunting. As first steps usually are, the plan is simple.

The plan is this—that a committee of highly qualified representatives from landowners, sportsmen, wildlife agencies, and legislators be named to explore thoroughly the possibilities and come up with the basis for a mutually acceptable plan. To my knowledge, this approach has not yet been tried. This is in the American tradition of having the people directly concerned, and

who are most familiar with a problem, meet and work out a solution.

What can be accomplished by naming such a committee? First, it is a specific and concrete step toward recognition and solution of the problem: the very existence of such a committee is progress. Secondly, the methods for making payment are unlimited and a group of this type would have the collective background to sift these through and arrive at a practical, workable plan.

The advantages of taking the initiative in developing a plan are obvious—legislation, initiated and sponsored by the wildlife agencies, acceptable to the sportsmen and equitable to the landowner.

What of the advantages to the hunter? The obvious answer is a place to hunt. And it is entirely possible and even probable that through a payment system, more habitat would be maintained, making larger bag limits possible.

On the basis of the national survey of fishing and hunting (*ibid.*), we now know what we had earlier expected—that hunting is a big business—big enough to demand the collective attention of the many directly affected groups.

It has been the purpose of this paper to review the problem, stimulate thinking on its urgency, and suggest that concrete though simple action be taken toward a solution. The matter is controversial, but the facts indicate a need for action. A fresh approach in managing private-hunting lands is in order.

The naming of such a committee would provide a new and successful approach to the problem of maintaining production habitat and harvest opportunity over a major portion of this nation's lands. Admittedly, the problems are great, but not insurmountable. By the same token, the stakes are high —the future of public hunting!

SUMMARY

The problem of shrinking production habitat and increasing public-hunting needs is reviewed as related to population increases, license-buyer density, and land ownership in the Midwest. Various management measures designed to solve the problem are discussed. It is proposed that the solution to the problem is to develop a system for compensating the landowner, and that this is the responsibility of the wildlife agencies. The legal and economic bases for the proposal are reviewed and examples cited. The paper proposes that a committee representing the various interests involved be named to work out a system of payment to the landowner, and that such a system is essential to the future of public hunting.

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CRITERIA FOR AGING PHEASANT EMBRYOS

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In the course of a series of experiments designed to investigate the conditions necessary to hatch pheasant (*Phasianus colchicus*) eggs by artificial incubation, the author found it necessary to establish the chronological appearance of aging criteria throughout the incubation period. The data collected deal with external characteristics visible without dissection, and are described herewith in nontechnical language.

Methods

About 2,500 embryos were examined in the course of this work, approximately 100 of each daily stage being used to establish an average growth at each recorded period. The eggs were obtained from penned birds at the Imperial Chemical Industries Game Research Station at Fordingbridge, Hampshire, England, over a period of four years, covering the laying seasons of 1951 through 1954. The eggs were laid by four types of pheasants: blackneck, Mongolian, Chinese, and melanistic mutant.

The majority of the eggs were incubated in cabinet and still-air machines, but a few were put under bantams as controls, to establish that no difference in embryonic-development rates existed between the two methods of incubation. Prior to incubation, the eggs were stored for not longer than seven days, since long storage tends to increase the incubation period slightly and causes some mortality at both the early and late stages of development. Eggs varied considerably in size, as did the embryos developed within them, but no significant difference existed in the growth rates as judged by the chronological appearance of the various criteria.

The variation in egg and embryo sizes made any measurement useless for the purpose of aging. The specimen embryos were preserved in 10 per cent Formalin, for detailed study at a later date, but observations on pigmentation, which might have been subject to bleaching in the preservative, were made on fresh embryos. Photographs of fresh embryos, taken for checking purposes and compared with Formalin-fixed specimens after storage for two years, showed that the macroscopic appearance, and even the pigmentation, was little affected.

General Patterns of Embryonic Development

The gross embryology of the pheasant differs little from that of the domestic chicken, despite the difference in length of incubation periods.

During the first few days, much of the growth energy of the embryo is employed in forming the embryonic membranes, which develop outside the actual body of the embryo and are known as extraembryonic membranes.

At the fifth or sixth day, these membranes having been initiated, more energy becomes available to the embryo itself, and a period of rapid growth begins.

By the fifteenth day, the embryo is practically fully formed so far as the foundations of the various organs and appendages are concerned, and development thereafter takes the form of elaborating and completing these structures.

After the fifteenth day therefore, with the exception of the spur papillae on the legs, no new criteria will appear, but development will take the form of a general increase in size and the further elaboration of features already in existence.

Embryonic Mortality

It should be borne in mind, when aging embryos which have died during the process of incubation, that some of the criteria may be difficult to identify because of postmortem changes.

Embryos that have died at an early stage of development may be unrecognisable after a long period of incubation, but stages from ten days onwards usually remain intact and show recognisable characters. In pheasants, there are three peaks of mortality that occur during incubation: an early peak up to 4 days, a mid-peak at 12 to 15 days,

and a final peak of dead-in-shell from the 20th day onwards. Candling should therefore be carried out at 8 days, and again at 16 days, so that dead embryos can be grouped into three categories.

A feature of avian incubation is the occurrence of dead embryos which have failed to respond to incubation and have died at the stage at which they were when laid, i.e., at gastrulation. These early deaths create some confusion in the minds of those who believe that unless a recognisable embryo is present the egg is infertile, i.e., unfertilized. The problem of identifying these casualties is one that causes some concern in both pheasant and poultry hatcheries. Fortunately, there is a fairly reliable method of distinguishing between a truly infertile egg and an embryo that has died at the gastrulation stage, provided at least seven days of incubation have taken place. The existence of a fertilized egg and partially developed embryo causes changes in the appearance of the egg contents after a period of incubation. An infertile egg remains, even after a full term of incubation, clear and palatable in appearance, with its yolk intact and unblemished. A dead embryo, in the gastrulation stage, almost invariably shows mottling of the yolk, the partial or complete breakdown of the yolk membrane, and sometimes putrefaction.

The term "fertile" is so loosely used in publications nowadays that the situation would bear clarification. An infertile egg is one that has not been fertilized. If an egg is infertile, no development will have taken place before laying, nor will any take place if the egg is incubated. A fertile egg has been fertilized. If an egg is fertile, some development will have already taken place prior to laying, and further development may or may not take place as the result of incubation. If a fertile egg has been damaged between the time it was laid and when it was set, the embryo may die. If such damage does not cause the embryo to die immediately, it may do so in the process of incubation, and such a damaged embryo rarely develops beyond a few days. It is therefore fairly safe to say that incubational casualties can be attributed first, to factors operating prior to setting—such as inherited weaknesses, nutritional deficiencies in the breeding hens, damage caused by motion during transport, long storage, or storage under incorrect conditions—and, secondly, to improper incubational practice. Casualties in the first category will generally take place in the early stages of incubation, whilst factors in the second category usually produce dead-in-shell in the final stages of development.

Analysis of Embryonic Mortality

Records of hatches, in a sample of about 5,000 fertile eggs giving an average hatch of 70 per cent, showed that mortality fell into three main groups: (1) those prior to the 4th day of incubation; (2) those of the mid-period from the 12th to the 15th day; (3) those in the final stages of hatching from the 20th day.

Based on the total embryonic mortality in a sample of 1,486 dead embryos, the first period accounted for 24 per cent, the second for 4 per cent, and the third for 72 per cent. Of the first-period casualties up to the 4th day, about 30 per cent took place at the gastrulation stage. The second period produced negligible casualties. The final stage showed the bulk of the casualties, and these occurred after the 20th day. Many embryos had broken into the air space, or even pierced the shell, yet failed to emerge. An analysis of these final-stage casualties showed that 58 per cent revealed no obvious reason for failure, whilst the remaining 42 per cent showed malpositions which could have been the cause of failure. Classification of malpositions under the seven standard groups (Marshall, 1948) gave the following results:

Position 1. Head between thighs, 13 per cent;
Position 2. Head in small end, 10 per cent;
Position 3. Head to left instead of under right wing, 4 per cent;
Position 4. Embryo rotated with the beak away from the air cell (often associated with very eccentric air cells), 35 per cent;
Position 5. Feet over the head, 17 per cent;
Position 6. Beak over right wing, 19 per cent;
Position 7. Embryo across egg, 2 per cent.

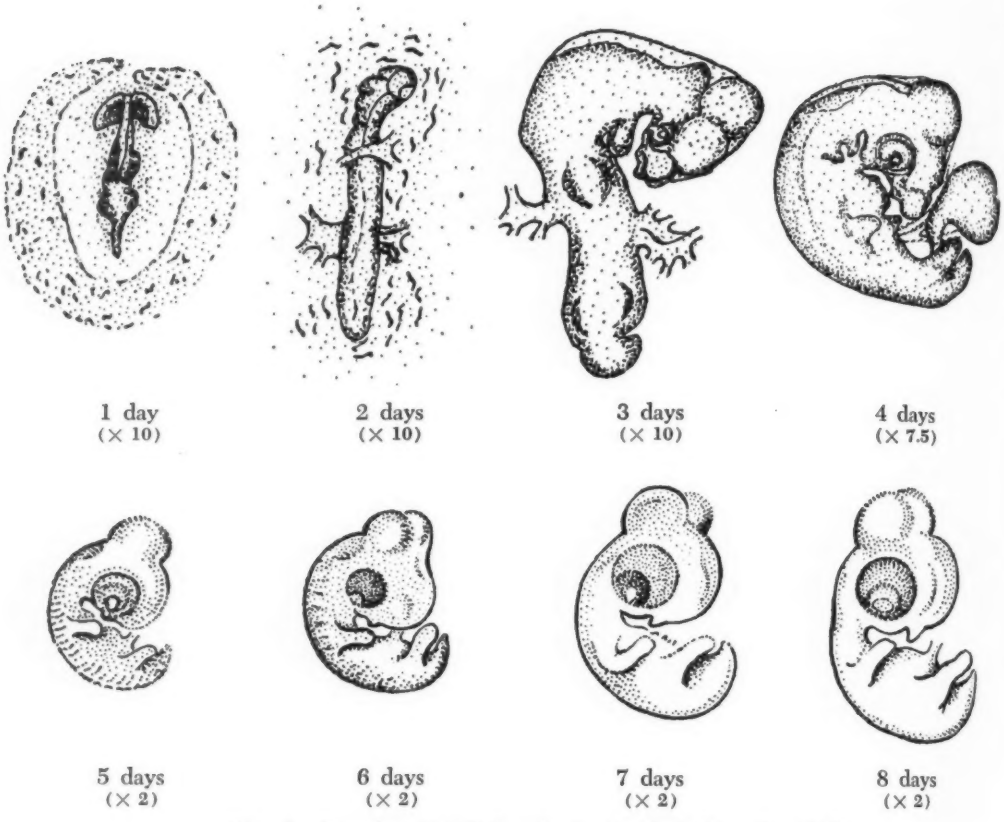

FIG. 1. Development of the pheasant embryo from 1 to 8 days.

DEFORMATIONS AND MALFORMATIONS

Abnormalities, such as crossed beaks, parrot beaks, shortened legs, large heads, etc., were completely absent in the sample examined. Spraddled or splayed legs, which revealed themselves after hatching, were encountered to the extent of less than 2 per cent.

CHRONOLOGICAL SEQUENCE OF AGING CRITERIA

The sequence of development in the pheasant embryo is illustrated in Figs. 1 and 2. Criteria useful in dating the embryos are as follows:

1st day. The embryo lies in a straight line at right angles to the long axis of the egg. Blood islands begin to develop in the blastoderm surrounding the embryo, but no blood is visible. There are 4 pairs of somites.

2nd day. The head of the embryo begins to turn to the right. Both cranial (head) and cervical (neck) flexures begin to initiate the humpbacked stage. Optic vesicles are visible as bulges protruding from the forebrain. The heart now projects from the body and begins to beat. There are 18 pairs of somites.

3rd day. The embryo now shows a complete flexure from head to tail. It is humpbacked, as a result of the cranial and cervical flexures, and the tail curves inwards and forwards, so that the embryo has the appearance of a letter C. The eyes protrude and the cranium shows two pronounced bulges: a pair of cerebral hemispheres in front and the bilobed midbrain behind. The heart is now seen beating rhythmically, and

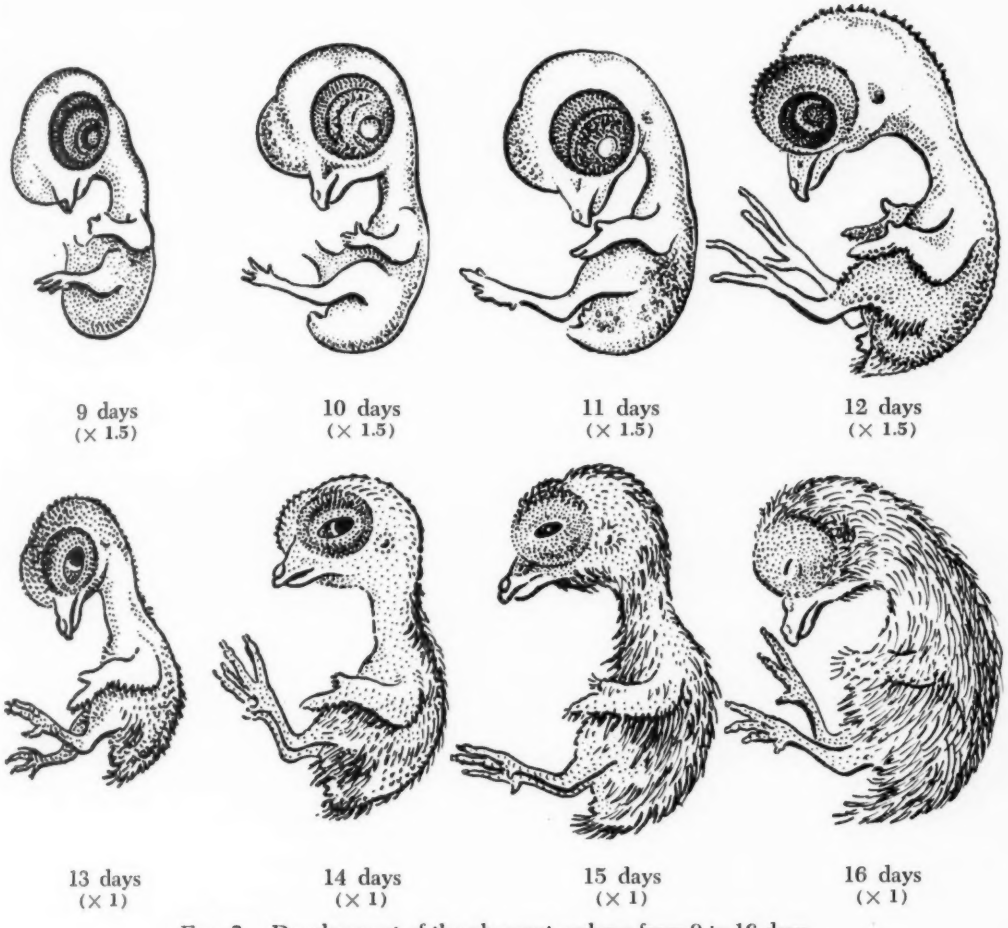

FIG. 2. Development of the pheasant embryo from 9 to 16 days.

blood is visible in the great vessels. There are 34 somites.

4th day. The eyes show the first signs of pigmentation. Limb buds are seen just beginning to differentiate from the body. The allantois develops as a stalked vesicle from the umbilical region. There are 40 distinguishable somites.

5th day. The embryo is now curved so that the pointed tail is almost in contact with the head. Both pairs of limb buds are now plainly visible as spade-shaped appendages lying close to the body.

6th day. Both the cerebral hemispheres and the bilobed midbrain are now very prominent. The upper mandible appears, and the embryo begins to acquire bird-like characteristics. The limb buds now project from the body.

7th day. The cerebral hemispheres are slightly reduced, but the midbrain remains very prominent. The upper mandible now projects from the face. The optic cup is almost closed, only a narrow space being visible in the lower sector of the eye.

8th day. The cerebral hemispheres are much less pronounced, but the midbrain is still very prominent. Limb buds are still more distinct, but show no digitation.

9th day. Both the forebrain and the midbrain are relatively much reduced in size, but the latter is still prominent. The eyes are now well pigmented. The

pipping tooth makes its appearance on the upper mandible as a tiny white dot. The alulae on the wings become evident as thumb-like projections from the manus. Digitation of the feet begins. The lower mandible is now well defined.

10th day. The midbrain still protrudes and breaks the curve of the cranium. The optic cup is now completely closed. The auditory opening becomes evident, and the nostrils are forming. The alulae are now completely separated from the manus. Digitation of the feet is clearly shown. Feather papillae develop on the spinal tract, on the head and on the thighs. The cloacal papilla is well defined.

11th day. The midbrain still shows a slight bulge. The nostrils are now well defined. The mandibles assume the normal beak-shape. Feather papillae are now evident on all feather tracts. The beak begins to harden.

12th day. The nostrils are well formed. Digitation of the feet is well advanced, and the metatarsals are clearly visible. Feather papillae are present on the eyelids. The tail is elongate, and tail feathering is beginning.

13th day. Pigmentation begins on the feathers of the spinal tract, over the thighs, and on top of the head. The cranium now shows a smooth normal curve. The eyelids are closing to normal size, and show an oval aperture. The lower limbs show advanced digitation and the deposition of keratin at the tips. There are scales on the legs and feet.

14th day. Pigmentation of the feathering continues. The keratinisation of the claws continues, and the tips of the digits show white casts. A complete ring of pigmented feather papillae is seen around the auditory opening. Scales are now well developed on the front of the legs.

15th day. The eye slit is almost normal in shape. Pigmentation of the plumage continues. Spur papillae are visible on the legs.

16th day. The eyes are still slightly protruding but rapidly assuming normal proportions. The eyelids show almost normal apertures. The cloacal papilla is retracted. Claws on the toe digits are well developed. Scaling on the legs is proceeding. Feathering is well advanced.

17th day. The feather tracts widen and develop rapidly. Pigmentation is also proceeding rapidly. The upper and lower mandibles are almost normal. The embryo is now in position for breaking out.

18th day. The size of the eyes is now normal in relation to the head. The nostrils are fully formed. The pipping tooth is still covered by a membrane. Webbing between the base of the toes is just evident. Scales and claws harden, and the beak is now rigid.

19th day. The eyelids are well feathered and closed. The spur papillae lie 1/8 inch from the metatarsals and slightly on the inside of the mid-line of the tarsal bone. Scaling of the legs is practically complete, the plantar surfaces being particularly well scaled.

20th day. Claw formation is complete. Feathering is practically complete. Webbing of the toes is complete.

21st day. The pipping tooth breaks through the membrane on the tip of the beak, and is now ready to perform its appointed function. The lower mandible is now equal in length to the upper one. The conical spur papillae are now plainly visible (in both sexes) just above the backward projecting digits of the feet.

22nd day. The head is completely feathered. The yolk sac is now completely withdrawn into the body cavity.

23rd and 24th days. Hatching begins.

SUMMARY

The mortality of pheasant embryos during incubation is discussed, together with the chronological appearance of visible criteria for the purpose of establishing the age at death or backdating clutches in nests encountered in the field.

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THE FALL SHUFFLE IN CENTRAL MISSOURI BOB-WHITES[1]

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The regrouping of bob-whites (*Colinus virginianus*) to form coveys and the shift from summer to winter range, known as the fall shuffle, has long aroused the interest of observers. During the nineteenth century, mass movements of quail in the fall were recorded many times (Schorger, 1944); these movements were perhaps the fall shuffle in irruptive populations. Quail are still noted on city lawns and buildings during the shuffle (Bennitt, 1943; Murphy and Baskett, 1952). Such spectacular appearances have helped create the impression that fall is normally a period of high mobility for bob-whites, although Leopold (1931:51) wrote that probably only some of the coveys of an area are affected and that movements even of these probably seldom exceed 3 miles.

In the southeastern United States and in Missouri, movements recorded for bob-whites during the entire fall and winter period have been for short distances. In Georgia, Stoddard (1931:174) found that only 20 of 94 birds banded in fall and recaptured or shot within five months moved more than 0.25 mile from the banding point. The average distance moved by these 20 was only about 0.35 mile. In central Missouri, Murphy and Baskett (*op. cit.*) found that four out of 18 adults banded in summer and recaptured in winter had moved more than a mile. But nine coveys containing banded birds were very sedentary. In a study conducted subsequently on the same area, Lewis (1954) reported that all of 79 birds supplying fall and winter movement records were recaptured within 0.5 mile from the first trap site.

In the southwestern United States, at the periphery of the bob-white's range, somewhat longer movements have been recorded or at least suspected. Eleven birds banded in northwestern Oklahoma during August and September by Davison (*in* Duck, 1943) were recovered in December at an average distance of 9.7 miles (extremes: 3 and 26 miles). In Texas, fall movements of 49 bob-whites banded by Lehmann (1946) in October and retrapped in November of the same year averaged about 0.2 mile (extremes: 0 and 0.46 mile). In the following year, the average for 97 birds was 0.22 mile (extremes: 0 and 3.1 to 3.7 miles). The longest movement was made by nine members of one covey.

In Lehmann's study, there was evidence of considerable movement to and from the 960-acre study area between autumn and late winter; thus, the distances he recorded for banded birds often may have been exceeded.

Among observations of coveys in Wisconsin, Errington (1933) noted only one instance of extensive movement: a covey moved about 1.5 miles before establishing a distinct covey range. However, the majority of Errington's observations were made in winter rather than fall. A more recent study (Buss, Mattison, and Kozlik, 1947) indicated that spring, rather than fall, may be the period of greatest movement for bob-whites in Wisconsin. This conclusion was based on evidence of ingress to a study area; movement data were not given.

The regroupings of quail leading to covey formation were described by Stoddard (*op. cit.*) He noted (p.44) that the merging of broods or the adoption of orphans by a brood took place whenever such birds met during the summer or fall.

Stoddard's banding showed the covey to consist of ". . . one to three pairs of adults and their surviving young, with the addition frequently of one to several unmated cocks, or of pairs that fail to bring off broods" (*ibid.*:169). The unmated cocks joined the coveys at any time in the summer,

[1] Contribution from the Missouri Cooperative Wildlife Research Unit: U.S. Fish and Wildlife Service, Wildlife Management Institute, Missouri Conservation Commission, Edward K. Love Foundation, and the University of Missouri cooperating. The writer is indebted to T. S. Baskett, who directed the research, and to Max Hamilton, R. S. Campbell, D. Q. Thompson, W. H. Elder, D. R. Progulske, and P. C. Smith for advice and assistance.

but the unsuccessful pairs ". . . are apt to come in late, for they seldom abandon nesting before the middle of September." He added that greater densities led to more diverse relationships of birds within coveys.

OBJECTIVES AND PROCEDURES

The present study, designed to investigate the fall shuffle in a number of marked bobwhites in central Missouri, was conducted between June, 1953 and March, 1954. The quail were studied on an area in Boone County measuring 6 by 2 miles. One-third of the area was gently rolling, intensively cultivated farmland with narrow wooded stretches along waterways. The remainder was hilly, with little cultivation and many abandoned fields plus second-growth oak-hickory woods on the slopes. The latter portion included the area described in detail by Murphy and Baskett in 1952. Probably because of drought, quail populations were low: in the hilly part of the study area the winter density was one bird to about 20 acres. Hunting was permitted over most of the study area.

In summer trapping of whistling cocks, a modified version of the "cock-and-hen" trap (Stoddard, *op. cit.*:446) was used. This trap, with a decoy hen confined inside, was placed close to a whistling cock. The trapper, seated nearby, was camouflaged by a piece of green muslin which he draped over himself. By imitating the hen's call, he attracted the cock to the trap. This procedure proved more efficient than relying on the female to attract the male initially.

In fall and winter trapping, Stoddard "cock-and-hen" traps baited with grain were set at coverts frequented by a covey or a family group. When a few birds were captured, they were marked and placed in a clover-leaf type trap (similar to that described by Low, 1951) set nearby. These birds frequently decoyed others from the same group into both traps.

Each bird captured was marked with a numbered aluminum leg band and a plastic field-recognition tag of the type described by Wint (1951). For the trapped birds in postjuvenal molt, the length of the most recently molted primary was used to determine the age and calculate the hatching date according to the tables published by Petrides and Nestler (1952). This information was used to detect mixing of broods.

Records of summer movement were secured by recapturing banded birds. Also, during fall and winter, sight records were obtained on birds in families or coveys whose records were well known. These records were used when counts of birds agreed with expected numbers and when marked birds were included.

During the nine months of this study, 248 quail were captured at least once. Summer trapping provided marked adults, the fall movements of which could be followed; most of these were males that were probably unmated (Stoddard, *op. cit.*:98). Winter trapping provided movement records from previously marked birds and furnished information on covey composition.

Fall was considered to start on August 1, when whistling declined markedly (although some was heard as late as August 20). Stoddard (*ibid.*:102) believed that whistling ceased at the time unmated males joined broods. The arbitrary terminal date for fall was December 1, when covey ranges were at last well defined.

OBSERVATIONS AND RESULTS

RELATIVE MAGNITUDES OF MOVEMENT

An index to the magnitude of summer movements was obtained by measuring straight-line distances from the point of first capture in summer to the most distant point of recapture for each bird during that season. For 11 birds, these distances averaged 693 yards or 0.39 mile (extremes: 0 and 2,200 yards). In fall, similar distances for 33 birds averaged 242 yards or 0.14 mile (extremes: 0 and 550 yards), while in winter, the distances for 38 birds averaged 142 yards or 0.08 mile (extremes: 0 and 600 yards). Thus, the movements of banded birds in summer were significantly greater at the 0.01 level than those of fall ($t = 3.956$ with 42 *d.f.*), and fall movements were significantly greater at the 0.01 level than those of winter ($t = 2.922$ with 69 *d.f.*). However, fall and winter trapping sampled the entire population, while summer trapping sampled males only.

FALL MOVEMENTS OF SUMMER-TRAPPED COCKS

Of 98 whistling cocks marked during summer, 19 were later found in coveys. For 11

of these, the coveys joined were those nearest the cocks' last summer trap sites. Distances between the last summer and first covey trap sites averaged 385 yards (0.22 mile). The other eight cocks all joined coveys near their summer ranges, but not those nearest the last summer trap sites. For these, distances between last summer sites and first covey trap sites averaged about 755 yards (0.43 mile). The longest movement recorded was slightly over ¾ mile.

Nothing is known of the fall movements of the 79 whistling cocks that were not subsequently found in coveys. However, this does not necessarily mean that they traveled far, for fall trapping was done on approximately one-tenth of the area used for summer trapping.

MOVEMENTS OF FAMILY GROUPS

The approximate relationship of the fall family-group range to the winter covey range was determined for seven family groups. Intensive trapping provided records of movements of from one to five birds of each group through the period of the fall shuffle. The following conclusions were reached.

1. At least parts of the ranges of five families overlapped the boundaries of the ultimate winter covey ranges.
2. Family and covey ranges for one group were adjacent.
3. The family and covey ranges in one case were separated by about 200 yards. However, no other covey range was nearer.

Three additional family ranges could not be ascertained. The covey ranges lay close to an early-fall trap site for each, but since these families were found late and in areas that had been searched many times, it is probable that unrecorded movements were involved.

Because of overlapping of ranges of some family groups with the ranges of the coveys to which they ultimately belonged, it was impossible to tabulate distances moved from family to covey ranges. However, a general impression of the extent of movements during this period was gained by considering the distances between the two most widely separated autumnal trap or observation sites for 35 birds first captured as members of family groups. For 24 of them, these distances were less than 400 yards, and the greatest distance recorded was 710 yards.

There are weaknesses in the data pertaining to range readjustment by family groups: in only one case was an entire family banded; also, about 40 per cent of the birds marked in these broods were not handled after the readjustment of ranges took place. But no evidence of egress was noted, despite the possibility of hunting recoveries outside the study area. This suggests that natural mortality and inefficient winter trapping accounted largely for the failure to recapture these birds. An additional weakness is the possibility that a few of the families (even those whose fall family-group ranges were well known) had already moved from their points of origin before they were found.

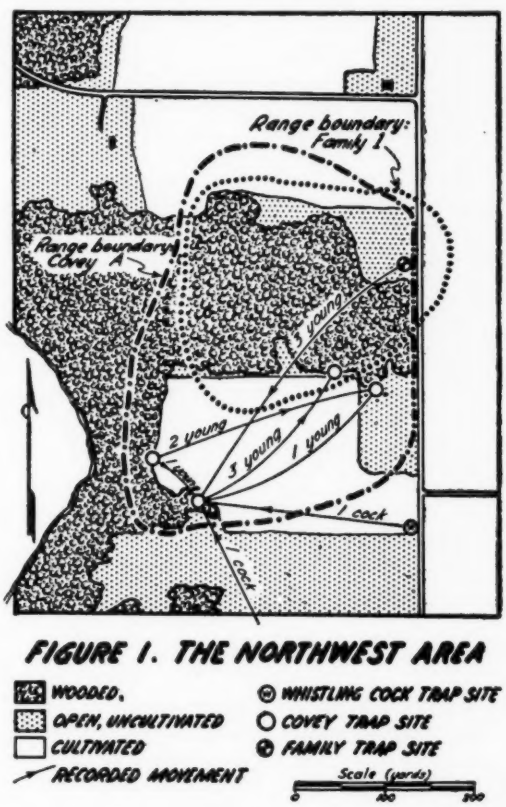

FIGURE 1. THE NORTHWEST AREA

PATTERNS OF COVEY FORMATION

Nearly all the data bearing on covey formation were gathered on three small areas within the large study area. Maps of two of these areas (Figs. 1 and 2) show the

arrangement of major vegetation types, and the ranges known to be used by each covey and family. Detailed accounts of the coveys on the two mapped areas illustrate patterns of covey formation.

Covey of the Northwest Area (Fig. 1).—*Family No. 1* was first located on August 9, when the young were about five weeks old. This group of ten birds, five of which were subsequently marked, ranged along the

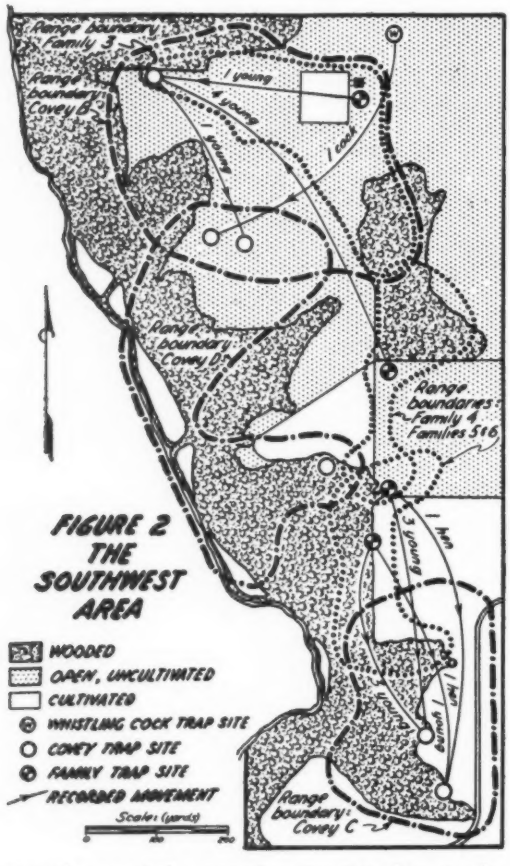

FIGURE 2 THE SOUTHWEST AREA

periphery of the woods. By October 3, the family, then reduced to eight birds, ventured west and southward along the woods edge and was found on that date with family No. 2.

Family No. 2 was not found until October 3, despite repeated searches of the area. Five young from this family were trapped. They were about two weeks older than those of family No. 1.

Formation of *Covey A* was first suspected from the observation on October 3, and was verified by trapping the following day. Joining of substantial portions of families No. 1 and No. 2 was corroborated, and the incorporation of two banded males into the group was discovered. An unbanded pair was also present; they were perhaps the parents of one of the broods.

The two banded males had been trapped during the summer as whistling cocks. One was seen whistling and apparently unmated, as late as July 31, just outside the area that was to become the covey range. The other male was last handled as a whistling cock on July 17, 515 yards southeast of the October 4 trap site.

Thus, by early October, *Covey A* consisted of: (a) three young from family No. 1, (b) five young from family No. 2, (c) a pair of previously unmarked adults believed to be the parents of one of the broods, and (d) two marked adult cocks, which apparently had not mated.

Three of the five young banded with family No. 1 were trapped on October 4; at least one of the remaining two had died by that date. This covey was subsequently flushed several times, but was not retrapped until late February, when six of the eight birds remaining in it were captured. All six had been present in the covey on October 4.

Coveys of the Southwest Area (Fig. 2).—*Family No. 3* was first located on September 5 when the young were about two months old. Repeated flushings showed that the group consisted of four birds. Only one, a young male, was ever trapped. They were frequently found at a vacant farmstead, near fields of Korean lespedeza and ragweed.

Family No. 4 was found on September 28, when the young were five or six weeks old. All of the seven chicks and one adult female were marked before they abandoned the family range. They ranged in a pasture, lespedeza field, and grazed woods; there was little ground cover in any of these.

For *families No. 5 and No. 6*, only one range is indicated on the map, and this probably includes the actual ranges of both. Although trapping showed them to be distinct families, the two were difficult to distinguish when flushed, and their ranges apparently overlapped broadly.

Covey B.—By October 28, five young

birds, one from family No. 3 and four from family No. 4, joined to form covey *B*; fates of other birds in both families were unknown, except that one young quail from family No. 4 died in a trap. The regrouping brought together birds from broods the ages of which differed by nearly six weeks.

Ranges of the families overlapped in the woods used as escape cover. The covey range was much the same as previously occupied by family No. 3 (the better-situated family), but it was expanded to include a portion of ungrazed woods to the west.

Covey C.—Mixing of families No. 5 and No. 6 was first detected in late October. By the first week of December, the two families were completely merged as covey *C*, and they moved about in the northern portion of the covey range. The southern portion of the covey range was apparently not occupied until two weeks later; this was the portion farthest from coverts frequented by the family groups.

By mid-January, the covey consisted of: (a) three young and one adult hen from family No. 6, (b) four young and one adult hen from family No. 5, and (c) one young bird of unknown origin.

In general, formation of covey *C* involved a minimum of readjustment, consisting merely of the merging of two broods already closely associated, with minor shifting and extending of range. The ages of the broods differed only by about ten days.

The whereabouts of birds that formed *Covey D* were unknown until the covey was discovered in December. Since upland portions of the area had been worked repeatedly with dogs throughout the fall, it appeared that the families contributing to it may have moved in from elsewhere.

Trapping showed this covey to include one adult male marked in June as a whistling cock, and 15 young, including one which was tagged with covey *B*.

REGROUPINGS

The family origins of the members of six coveys, including those described above, are summarized in Table 1.

From Table 1 and the preceding maps, it may be seen that four of the coveys studied intensively were composed of two families each, plus unmated males and possibly unsuccessful pairs. One covey originated from only one family, and family components of the remaining covey were not known. It should be noted that the largest covey of the six had 16 birds at its peak in November; coveys larger than this are often seen in Missouri. Thus, the findings agree rather closely with those of Stoddard (*op. cit.*), who found from one to three families contributing to coveys (p.169).

Stoddard indicated that merging of broods in summer occurred frequently in Georgia and Florida. Merging was not observed in this study until October, and in

TABLE 1.—FAMILY COMPONENTS OF SIX COVEYS

Family Number	Hatching Date	Total Number of Birds: In Family	Marked in Family	Retrapped in Covey	Covey Joined	Other Birds in the Covey
1	July 1	10	5	3	A	Two adult (unmated?) cocks
2	June 16	unknown	0	7	A	
3	July 9	4	1	1	B	None
4	August 20	8	8	4	B	
5	August 20	11	10	5	C	One young (origin unknown)
6	August 30	unknown	5	4	C	Two quail (not trapped)
–	—	unknown	–	–	D	Fifteen young and one adult cock
7	July 17	8	7	6	E	One adult (unmated?) cock One adult cock, two adult hens (origins unknown)
8	June 18	8	2	2	F	Two young, two adult cocks
9	August 6	9	9	3	F	(origins unknown)

the one case where the complete sequence of events was known, an unmated male joined the family well before family groups combined.

In all cases in which families with known ranges merged to form coveys, the family ranges adjoined or overlapped one another. This indicates that little social selection is exercised in the formation of these groups, and that merging probably results from random meetings of birds.

DISCUSSION

RELATIVE QUALITY OF FAMILY AND COVEY RANGES

Errington (*op. cit.*) believed that fall movement in Wisconsin resulted in the abandonment of "food-and-cover-impoverished" family ranges and re-establishment on range better suited to winter survival. In the present study, fall movements appeared to place birds of two families in covey ranges slightly better than their family ranges. However, analysis of vegetation types inhabited by all seven families whose ranges were well known showed no basic difference in the habitats used before and after coveys were formed.

IMPLICATIONS FOR MANAGEMENT

As was pointed out above, no quail in or with a brood was known to have moved more than 710 yards during fall or winter; most apparently moved less than 400 yards. This is an important consideration for the landowner, since it implies that a brood hatched near the center of a 160-acre farm probably would winter on the same farm. A farmer providing good nesting cover plus adequate fall and winter range for quail would usually be rewarded by having birds reared on his farm still present during the hunting season.

Since quail may be "drained-off" such managed areas during spring, estimates of minimum sizes of areas needed to hold birds throughout the year are considerably larger than 160 acres. These range from 1,000 or 1,500 acres as suggested by managers of quail preserves in the southeastern United States (Scott and Klimstra, 1954) to 4 square miles in Missouri (Murphy and Baskett, 1952), and a township in Wisconsin (Thompson and Mattison, 1950).

SUMMARY

This study was undertaken to provide detailed information on the spatial and social changes exhibited by wild bob-whites in central Missouri during the fall period. Trapping was carried out on an area of about 7,500 acres during the period June, 1953 to March, 1954. All 19 of the summer-trapped cocks that were subsequently found in coveys appeared to make only short fall movements, and 11 of them apparently joined the first family group encountered. Birds from seven families were traced from the fall family ranges to the winter covey ranges. In six cases, the family and covey ranges overlapped or were adjacent; in the exception they were only 200 yards apart. In three other cases, the extent of movement was not known, but longer movements may have been involved. Four coveys were composed of two families each, plus unmated males and possibly unsuccessful pairs; one covey had young of only one family. The low mobility of these banded quail during fall suggests that, with adequate habitat, Missouri quail often rear their broods and establish winter covey ranges within a few hundred yards of the hatching point.

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GRAY SQUIRREL POPULATIONS IN EXTENSIVE FORESTED AREAS OF WEST VIRGINIA[1]

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During a recent study in West Virginia a total of 14,543 gray squirrels (*Sciurus carolinensis*) was sexed and aged over a period of six years on four areas ranging from 6,000 to 12,000 acres. The primary forest type on these areas was the red oak (*Quercus borealis*) type, interspersed with other forest types such as white oak (*Q. alba*) which occupied the richer soils on southern exposures, the chestnut oak (*Q. montana*) type which occupied the high, dry and rocky ridges, and the yellow poplar (*Liriodendron tulipifera*) type, found on the cool moist slopes along the banks of streams, or on slopes that face north and east.

TECHNIQUES

Hunters checking in and out of the areas provided information pertaining to gun hours and hunter success. In 1953 it was determined that the kill per 1,000 acres during the first 1,000 gun hours gave a reasonable estimate of the population level (Uhlig, 1956a). On Seneca State Forest this method was also checked for three years by time-area counts and modified leaf-nest censuses (*ibid.*).

Aging methods as outlined by Allen (1943) in Michigan and Brown and Yeager (1945) in Illinois were used, and information gathered on age ratios proved to be valuable.

POPULATION FLUCTUATIONS AND MORTALITY

Population Fluctuations

On a state-wide basis, 1951 and 1954 were peak years, although the data clearly show that each area had its own population characteristics.

Generally, annual fluctuations in local small-game populations are attributable to two causes: variation in annual production of young and variation in annual losses of adults. During this study the adult density varied comparatively little on each individual area (Table 1). The survival percentages are given in Table 1, but the writer believes that the estimated density of adults provides a clearer picture of the annual survival.

Annual fluctuations in total population density on the areas sampled appeared to depend primarily upon the number of juveniles in the autumnal population and not upon the survival of adults.

Population Density and Mortality

There was a distinct correlation between population density in one fall and subsequent mortality the following year (Fig. 1). Apparently such a relationship also occurs

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TABLE 1.—ESTIMATED POPULATION DENSITIES OF ADULT AND JUVENILE GRAY SQUIRRELS PER 100 ACRES ON 4 STATE FORESTS

State Forest	Year	Size of Sample Aged	Per Cent Juvenile	Estimated Density			Season Kill	Per Cent Survival from Previous Year[1]
				Total	Adults	Juveniles		
Seneca (10,671 acres)	1949	474	65	148?	52?	96	4.5	—
	1950	851	47	47	25	22	8.0	17
	1951	1,111	80	60	12	48	10.7	26
	1952	611	74	43	11	32	5.9	18
	1953	130	67	33	11	22	1.6	30
	1954	1,438	78	117	26	91	14.6	72
	Average	—	70	74	22	52	7.5	33
Coopers Rock (12,212 acres)	1949	699	54	28	13	15	6.5	—
	1950	369	62	21	8	13	3.0	27
	1951	409	55	45	20	25	5.4	95
	1952	460	58	43	18	25	4.6	40
	1953	346	67	30	10	20	2.0	23
	1954	362	41	22	13	9	3.0	43
	Average	—	58	31	13	18	3.8	46
Kanawha (6,843 acres)	1949	564	53	47	22	25	8.2	—
	1950	834	53	49	23	26	12.2	49
	1951	378	38	26	16	10	5.5	33
	1952	256	60	45	17	28	4.7	65
	1953	472	70	84	25	59	8.5	56
	1954	1,240	61	79	31	48	19.0	37
	Average	—	60	55	22	33	9.7	48
Cabway-lingo (6,476 acres)	1949	256	52	52	25	27	4.0	—
	1950	436	53	43	20	23	6.7	38
	1951	833	—	99	aging error	—	12.9	42
	1952	450	62	60	23	37	9.0	23
	1953	496	71	101	29	72	10.0	48
	1954	1,068	57	95	41	54	19.5	43
	Average	—	56	75	26	42	10.3	39
	Total	14,543						

[1] Calculated by dividing the adult density by the total density of the preceding year.

in ruffed grouse (Bump, Darrow, Edminster, and Crissey, 1947:370). By combining the data collected on all forests, the relationship between the total population density and the subsequent mortality to the next fall may be expressed by the formula, $Y = 0.753X - 7.4$, where Y is the expected mortality per 100 acres during the year following a population density of X (Fig. 2). The coefficient of determination (r^2) was 0.874. This was interpreted to mean that approximately 87 per cent of the changes in mortality could be explained by changes in total population density of the previous fall.

Since the data for this line of regression were obtained over a period of years, it probably represents a relationship for years of average mast conditions. Fluctuations above and below the line were probably due to varying food supplies, fluctuations in weather conditions, predation, disease, etc. The relatively small degree of dispersion along the line shows that these factors combined did not vary greatly in their effect on mortality or survival. Apparently mortality due to these causes depends primarily upon fall population density. The higher the density, the greater the influence of these factors.

Density of Juvenile Population and Mortality

A further analysis of data for the forests indicated a distinct parallel in trend between the juvenile density and mortality (Fig. 3). Summer juveniles are possibly

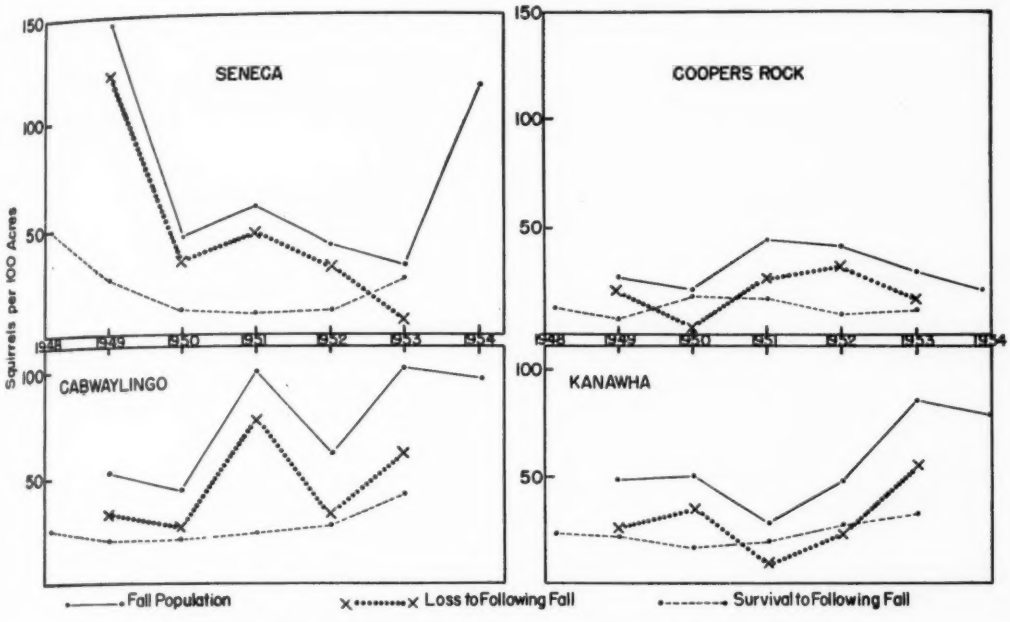

FIG. 1. Relationship between fall population, adult survival, and mortality.

the first to die, followed by the older and more experienced spring juveniles and adults. However, this is only conjecture. The important point is that the fundamental carrying capacity of the area remains reasonably constant year after year despite the population density of the previous fall.

Combining the data for all forests, relationship between juvenile density and mortality may be expressed by the formula, $Y = 4.8 - 0.786X$ where X = the number of juveniles per 100 acres and Y = mortality (Fig. 4). Here the coefficient of determination was 0.672, indicating that 67 per cent of the changes in mortality may be attributed to changes in juvenile population density.

In brief, winter carrying capacities are relatively stable. A low fall population, which is the result of a low proportion of juveniles, suffers only a low mortality during the following winter. Conversely, high populations indicate a high proportion of juveniles, which in turn foretells a high winter mortality. As a rule of thumb for individual areas, we might say that squirrel mortality during any year is approximately equal to the number of juveniles present the previous fall, with no implication that it is only juveniles that die.

Mortality Factors

Population estimates and kill records indicated that an average of only 13 per cent of the population was bagged by hunters

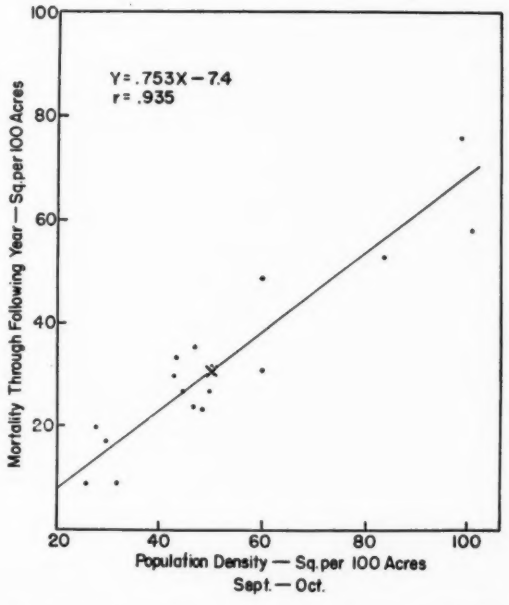

FIG. 2. Effect of population density on mortality.

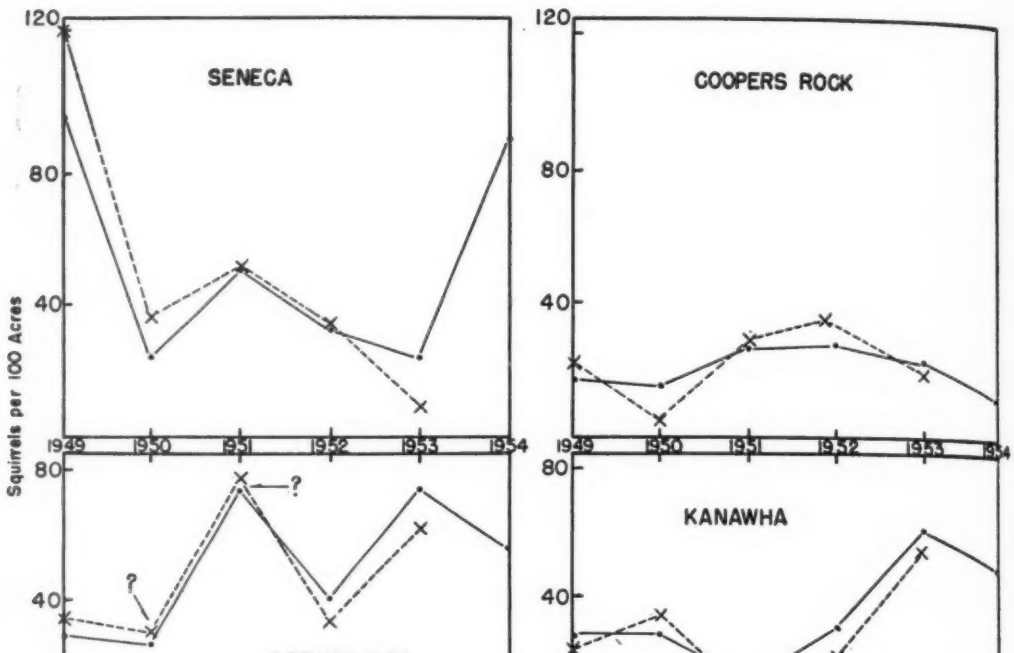

FIG. 3. Relationship between juvenile population density and mortality.

(Uhlig, 1956a, 1956b). The degree of influence of other mortality factors such as food supplies, weather, predation, and disease is not quite so clear. These factors varied annually on all areas, but the number of squirrels surviving seldom varied from the average more than 11 squirrels per 100 acres. Based on present data, food supplies and availability on these extensive areas influenced spring reproduction much more than survival or mortality of adults. Greater variation in survival was noted on Seneca Forest where weather conditions were much more variable and severe.

As a whole, variation in the number of squirrels surviving per 100 acres on each area showed that mortality factors cannot be evaluated individually. When the influence of one factor decreased, another increased. All mortality factors varied annually to some degree, but the over-all influence was comparatively stable and determined to a large extent by the fall population density.

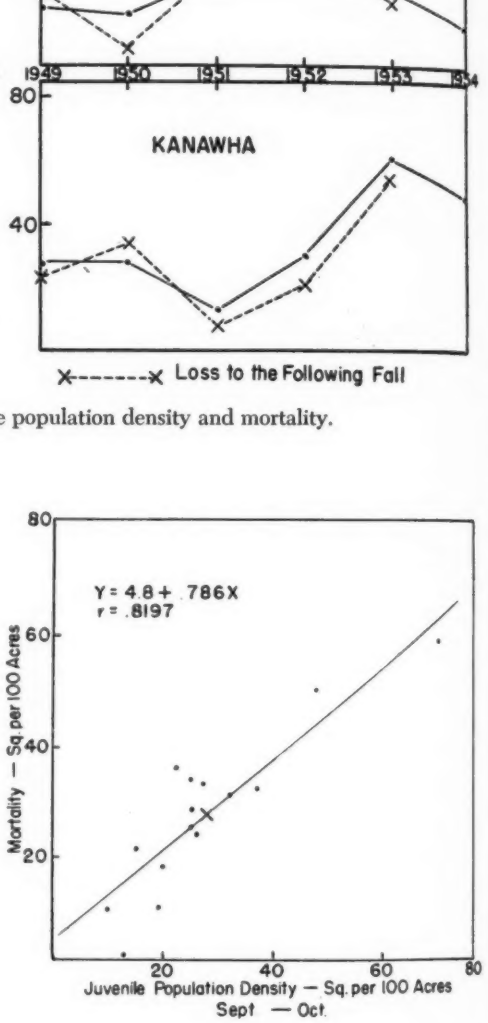

FIG. 4. Relationship between juvenile population and mortality.

POPULATION STRUCTURE

Sex and Age Ratios

Petrides (1949) stated, "There is a decided need for standard sex and age ratios to indicate approximately stable population conditions. Deviations either way then could be compared with standards to indicate reproductive efficiencies and probable population trends." During the present study, 62 per cent of the squirrels shot by hunters were young of the year (Uhlig, 1956b). Allen (1943) reported similar figures for fox squirrels (*Sciurus niger*).

Allee, *et al.* (1949) pointed out that the sex ratios of certain insects, particularly those with labile sexual potentialities, tend toward equality in small populations or have a preponderance of females, while denser populations tend toward maleness. In game populations, Allen (*op. cit.*) felt that more female fox squirrels were produced when the population trend was upward. Linduska (1947) observed that in the cottontail (*Sylvilagus floridanus*) low populations were associated with large proportions of males. Moran (1952) indicated that an increase in the female segment of a squirrel population was associated with rising populations and further recommended that sex ratios of young should also be considered.

On a state-wide basis males were predominant in either the adult or juvenile population in only two of the six years (Table 2). When age classes were combined, males were never dominant. On individual areas and in different years, making up a total of 30 cases, the results were quite different. The following discussion is based on the assumption that a preponderance of males is indicative of a lower-than-average or decreasing population.

During the investigation, adult males made up over 50 per cent of the adult population in only 11 out of 30 cases studied. Six of the 11 cases were associated with lower-than-average populations and five with higher-than-average populations. The same number was associated with decreases and increases in populations compared with the previous year, and it was found that nine cases were in favor of the assumption and 15 were unfavorable. It was concluded, therefore, that the changes in the sex ratios of the adult population do not appear to be associated with changes in population density, at least for this particular species.

In the juvenile segment of the population, males made up over 50 per cent of the population in only 12 of the 30 cases studied. Ten of the 12 cases were associated with lower-than-average populations and the same number with decreases in population, irrespective of the average.

The present evidence indicated that the juvenile male–female ratio usually is in favor of males, when lower-than-average densities or decreases in the population are present.

High proportions of females in either the adult or juvenile segment are not necessarily identified with higher-than-average or increasing populations. Decreases in popula-

TABLE 2.—SEX AND AGE RATIOS OF GRAY SQUIRRELS KILLED ON WEST VIRGINIA STATE FORESTS AND REFUGES

Year	Number Sampled	Per Cent Juvenile		Per Cent Males			Rearing Success[1]
		Both Sexes	Females Only	Ad.	Juv.	All Ages	
1949	1,958	56.5	60.7	52.7	43.2	47.4	2.72
1950	3,745	51.4	52.8	49.3	45.5	47.8	2.08
1951	4,087	71.5	70.2	45.4	48.8	48.0	4.62
1952	2,193	64.1	60.9	45.0	52.1	49.4	3.26
1953	1,444	66.9	72.5	56.8	43.6	47.9	4.67
1954	4,108	64.0	63.2	48.7	50.5	49.8	3.46
Total and Avg.	17,535[2]	62.4	62.2	48.6	48.0	48.3	3.17

[1] Young per adult female.

[2] An additional 2,992 squirrels included in this table and not in Table 1 were collected on Elk River Game Refuge, and Greenbrier and Panther State Forests.

tion occurred in 7 out of 18 cases when the sex ratio of the juvenile segment was in favor of the females. In the other 11 cases, when females were in preponderance, the population either remained nearly stable or increased.

It was also noted that the squirrel populations on two forests were identified with definite but different sex-ratio characteristics. Kanawha Forest was characterized by a preponderance of females in the juvenile segment of the population in all six years of study. This occurred despite fluctuations in populations. This forest received the heaviest hunting pressure of any area. Because estimates indicated that no more than 25 per cent of the population was ever taken in any one year, it seemed doubtful that the heavy hunting pressure was related to the preponderance of juvenile females.

The other forest, Cabwaylingo, located in the same general region, had a preponderance of females in the adult population in all six years. This forest was characterized by a higher-than-average survival (never below 20 squirrels per 100 acres). A low spring-rearing success indicated that only a small number of females had spring young.

Sex Ratios by Age Classes

Sex ratios also aided in determining differential sex mortality. Table 3 shows the sex ratios of 9,647 juvenile gray squirrels and 6,257 adult gray squirrels killed on state forests in October, 1949 through 1954. If juveniles are born in almost equal proportions, the ratios indicate that a differential mortality of males occurs. The 1949–53 ratios are considered normal, and it appears that a differential mortality of males continues through both of the juvenile age classes until adulthood is attained and then an apparent differential mortality of females occurs. This probably happens during the first winter or during the parturition periods. A high proportion of adult females and low spring-rearing success occurred on Cabwaylingo Forest and might be connected in some manner. Or it may indicate that females are more vulnerable than males during the October hunting season. This same progression was shown by Shorton (1951) to occur in England. In the nestling stage, she found a male/female ratio of 107/100, while in the juvenile stage a ratio of only 81/100. The adults were in a ratio of 85/100.

When the 1954 data are added to the ratios, there does not appear to be a differential mortality of juveniles. The year 1954 was one of higher spring-rearing success and improved hunting. It is therefore possible that a higher survival is indicated when a lower mortality rate occurs in spring juvenile males.

SUMMARY

A total of 14,543 gray squirrels was sexed and aged over a period of six years on four areas ranging from 6,000 to 12,000 acres in size. Annual fluctuations in total-population density appeared to depend primarily upon the number of juveniles in the autumn population and not upon the survival of adults, which varied comparatively little. There was a distinct parallel in trend between the juvenile population density and mortality during the following year. A correlation also was found between the total population density in the fall and the subsequent mortality during the following year. On two forests a decreasing population occurred when the juveniles comprised less than 62 per cent of the kill. Seventy-one per cent juveniles indicated an increasing

TABLE 3.—SEX RATIOS BY AGE CLASSES OF GRAY SQUIRRELS IN WEST VIRGINIA

Age Classes	Males per 100 Females 1949–53	1949–54	1949–53	1949–54
Summer juveniles	93	94	4,291	5,015
Spring juveniles	89	94	3,486	4,632
Adults	98	98	4,618	6,257
Totals			12,395	15,904[1]

[1] While a total of 17,535 were sexed and aged, this table is based on 15,904 that were also weighed in order that they might be divided into the two juvenile age classes.

population. Changes in sex ratios of adults did not appear to be associated with changes in population density. The juvenile male–female ratio usually was in favor of males when lower-than-average population densities or decreases in population occurred.

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AGE CRITERIA IN MALE GRAY SQUIRRELS[1]

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Age criteria in squirrels have been based previously on external appearance, particularly of genitals, mastology, and pelage (Brown and Yeager, 1945). Differences in these features in adults and juveniles show a high degree of correlation with rule-of-thumb skinning and "eating" tests, but more recent histological studies (Hoffman and Kirkpatrick, 1956) have shown that external genitalia of males are poor criteria for aging males because confusing similarity exists between developing juveniles and seasonally degenerating or redeveloping adults. From studies of male squirrel reproductive tracts, five arbitrary stages of sexual development have been recognized which are characterized by histological differences in testes and accessory glands (Kirkpatrick, 1955; Mossman, *et al.*, 1955; Hoffman and Kirkpatrick, *op. cit.*). In all these studies, age is regarded as being determined by the stage of sexual development. The adult squirrel is one that has developed fully functional reproductive tissues at some time, a condition signified by the simultaneous presence of sperm in the epididymis and secretion products in the Cowper's, prostate, and seminal glands. Any male that has not developed this condition is a juvenile.

Although the histological method gives a reliable separation of sexual development stages, which can be lumped into the two broad age classes of adults and juveniles, the method is not easily employed by all wildlife biologists. It is valuable when rapid, on-the-spot analysis is not necessary. As a laboratory procedure, it has been useful in checking the accuracy of field techniques (*ibid.*), and its further use to test new methods of aging is shown in this report.

In the search for simple criteria of age which are highly reliable without need for microscopic techniques, the skeleton quickly comes to mind. The weight, dimensions,

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[2] The authors are indebted to H. E. McKean, AES Statistics Office, for his analysis of the data.

and other physical characteristics of skull, teeth, long bones, and baculum have been studied in connection with age in a number of mammals. Examples of references to fur species are Friley (1949a, 1949b), Sanderson (1950), Marshall (1951), Elder (1951), Robertson and Shadle (1954), and Lechleitner (1954), all of which contain additional references. In small-game mammals, the results of X-ray examinations of long bones have been described for cottontails (Thomsen and Mortensen, 1946; Hale, 1949) and squirrels (Petrides, 1951). In these studies, the presence or absence of epiphyseal cartilage was used to separate adults from young of the year. Hale (*op. cit.*) also observed that age differences could be detected by scraping the bone in the region of the epiphyseal cartilage as a test for persistent or ossified cartilage. As an age criterion in squirrels, the baculum has not been reported upon, although Prasad (1951) states that by a study of baculum weights of the palm squirrel (*Funambulus p. palmarum*) it is possible to classify adults or young, but he omits further details. The bone has been studied for purposes of sciurid taxonomy (Howell, 1938; Wade and Gilbert, 1940; White, 1953; see also Prasad, 1954, for references to bacula in Asian squirrels).

The purpose of the present work was to search for skeletal age criteria in the gray squirrel by comparing various skeletal dimensions and the condition of the epiphyseal cartilage with the age of each animal as determined by histological examination of the reproductive tissues.

MATERIALS AND METHODS

The study is based upon 108 male gray squirrels (*Sciurus carolinensis*), of which 7 to 11 were live-trapped in each month of the year in the vicinity of West Lafayette, Indiana. After the animals were chloroformed, the squirrels' reproductive organs were removed and fixed in Bouin's or A.F.A. at once. Standard methods of dehydration, embedding, sectioning, and staining were used for the soft tissues in preparation for microscopic study. The baculum, humerus, femur, and skull were removed from each squirrel, and all but the baculum were roughly cleaned of muscle. Part of the bones were cleaned by dermestids and part by boiling in water. Later, for the sake of uniformity, all bacula were boiled vigorously in water for 30 minutes and air dried for several weeks before weighing.

The entire series of these materials was studied in two steps. In one step, the testes and accessory gland sections were studied, and the sexual development of each squirrel was determined according to the method of Mossman, *et al.* (*op. cit.*). Squirrels in infantile and prepubertal stages were lumped to comprise the juvenile age class, and all others comprised the adult age class. With all specimens thus accurately assigned to a known age, there remained only the measurement of skeletal parts and analysis of these data in searching for differences between the two age groups.

The baculum was weighed to the nearest one-half milligram on a Roller-Smith precision torsion balance. Other bone and skull measurements were taken with a vernier caliper to the nearest one-tenth millimeter. Five skull dimensions were measured (Table 1). These were chosen with reference to Gould and Kreeger (1948) where they are described for the muskrat (*Ondatra zibethica*).

A visual inspection was made of the cleaned, dried leg bones to classify the condition of the cartilage between the epiphysis and diaphysis.

RESULTS AND DISCUSSION

From the histological analysis of testes and accessory glands of reproduction, including prostate, Cowper's gland, seminal vesicle, bulbar gland, and epididymis, we found the 108 specimens to comprise 30 juveniles and 78 adults. Since 31 of the adults were either in degenerating or redeveloping stages, in all probability the adult group included more than one year class, implying that some of the older individuals would exhibit maximum skeletal measurements. In this paper, we cannot attempt to explain the unusual age ratio, but it does appear that the sample might have been influenced by an unknown bias that favored the live-trapping of adults.

As noted before, this method of aging unknown squirrels is based upon cellular differences in reproductive tissues as seen microscopically, and reveals the physiological age of the male in terms of reproductive capacity. Although the histological proced-

TABLE 1.—DIFFERENCES BETWEEN JUVENILE AND ADULT SKELETAL MEASUREMENTS IN MALE GRAY SQUIRRELS

Measurement	Number of Animals and Range		Mean		Difference	t*
	Juvenile	Adult	Juvenile	Adult		
Baculum weight (mg.)	27 14.0–28.5	75 24.0–45.0	20.46	33.25	12.79	15.32
Baculum length (mm.)	26 9.0–10.8	75 10.2–12.1	10.07	11.25	1.18	10.12
Femur length (mm.)	25 38.5–55.9	69 50.0–57.5	51.13	53.99	2.86	3.44
Humerus length (mm.)	25 32.0–45.9	73 41.0–46.8	41.78	43.62	1.84	3.05
Skull length (mm.)	23 49.0–61.5	73 55.5–62.3	57.05	59.34	2.29	4.01
Cranial width (mm.)	23 22.8–25.8	75 23.7–26.1	24.54	24.92	0.38	2.15
Zygomatic width (mm.)	23 28.4–34.1	74 32.0–35.6	32.36	33.75	1.39	4.61
Occipital height (mm.)	27 14.6–17.0	74 15.0–17.2	15.73	16.09	0.36	1.78
Lower tooth-row length (mm.)	25 9.3–10.8	68 9.0–11.0	10.25	10.20	0.05	0.54

* All differences significant at 5% level ($t = 2.0$) except occipital height and tooth-row length.

ure is critical enough to make distinctions in stages of sexual development from infancy to maturity and beyond into degeneration and redevelopment, no attempt has been made to relate these stages positively with age in terms of birth dates or months of life. In general, it is assumed that juveniles mature at around 11 months of age or a little later, as evidenced by sperm storage in the epididymis and the activity of secretory epithelium in the accessory glands. Males found in the seasonally degenerating or redeveloping states are in their second year or older.

The results of correlating skeletal measurements with age classes are given in Table 1. It is evident that the means of all juvenile and adult measurements exhibit differences to a large or small degree in the various items measured. In all cases except lower tooth-row length, the mean of adult measurements exceeds that of the juveniles. It is also clear that considerable overlap in individual measurements exists between the ages. As shown by frequency distributions for all measurements except baculum weight (and possibly baculum length), the overlap is so extensive that any age-indicative value from a single measurement is questionable except under certain conditions discussed below.

The Baculum

While it is not the purpose of this paper to present a morphological description of the gray squirrel baculum, the bacula studied by us are different from those described and figured by Wade and Gilbert (*op. cit.*), so an explanation may be necessary. The 102 bacula in our collection, as well as about 50 fox squirrel (*S. niger rufiventer*) bacula that we have examined, lack the ossification of the ridge or crest which those workers state becomes "firmly ankylosed," i.e., attached by ossification, to the distal disc of the baculum. Their figures for gray and fox squirrel bacula support their observations that the ridge is a true part of the os penis. They also observe that the ridge is nearly always lost in cleaning the bacula of juve-

niles, and that it is bony only in fully adult males.

We agree that there is an accessory ridge to the baculum. Embedded in the tissues of the glans, a spiral, wing-like accessory rises on the convex side of the baculum disc, passes in the form of an arc over the dorsal part of the baculum, and ends at its base. We found that the free edge of this process, which is hard and sharp, is cartilaginous, since it twists and shrinks when boiled and then dried. The process was not ossified to any of the squirrel bacula we cleaned or examined, and the smooth, shiny periostea of all the adult bacula fail to suggest the fracture of integral parts during cleaning (Fig. 1). Howell's (*op. cit.*) figure of the gray squirrel baculum is similar to ours, and with reference to Thomas' (1915) work, he states that it is essentially like that of *S. vulgaris,* the European red squirrel. In a thorough histological study of the os penis of *S. vulgaris,* Krölling (1921) shows that the accessory ridge is cartilaginous in old males, and describes the point of attachment to the disc as fibrous. We believe these evidences support our observations that the gray squirrel baculum is a simple shaft, uncomplicated by fragile bony accessories.

The baculum offers a convenient method for aging male gray squirrels. Its location within the last one-half inch of the distal end of the penis renders it easily found and collected from the hunters' kill without objectionable mutilation of the carcass. The portion that must be collected to get the bone is small enough to be mailed easily in a standard-sized envelope, thus facilitating state-wide collection. The bones may be cleaned by dermestids, but for critical weighing to fractions of a milligram, we found it best to follow such treatment by boiling in water, later rubbing the bones with cheesecloth to remove minute fragments of connective tissue. Even so, some connective tissue remains inside the hollow funnel-like shaft of the baculum which suggests that measurements of length may portray differences more accurately than weights.

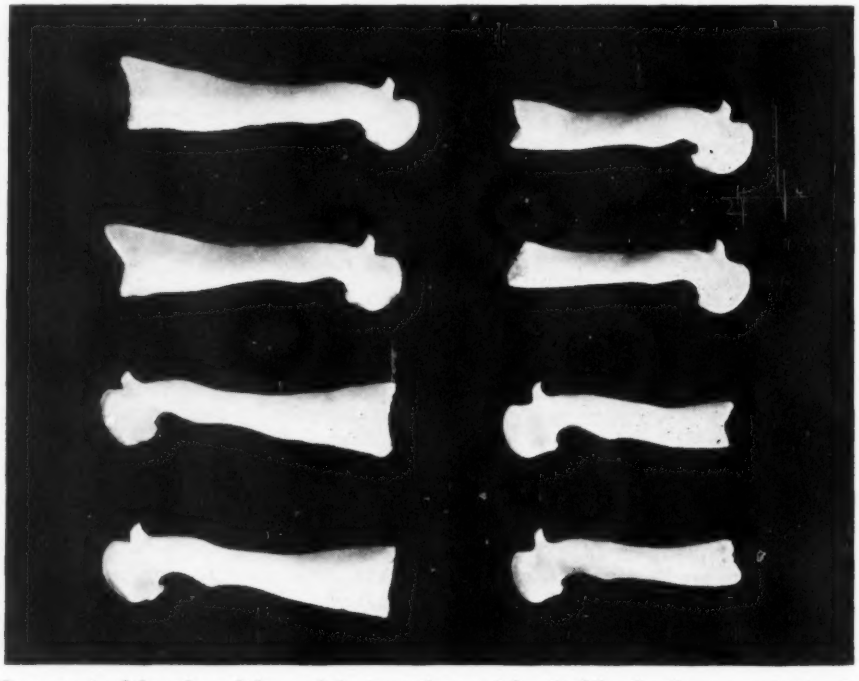

FIG. 1. Gray squirrel bacula, adults at left, juveniles at right. In life, the thorny projection is posterior and the distal disc is ventral due to the strong ventral flexure of the penis tip. Top two rows show the left side, bottom two rows show the right. (Three times natural size.)

As they appear to the eye, juvenile and adult bacula are not markedly different except that the adult bones are slightly longer and more flaring at the funnel or base. At that point the adult enlargement is more conspicuous than changes discernible in the disc, projecting hook, or tapered shaft. Since the latter parts are more or less constant in size, the expanded base perhaps is built up by continued ossification of connective tissue filling the cavity of the funnel or attached to it, and probably contributes most to increases in weight and length of the bone.

Both weight and length of the baculum are useful age criteria. It may be observed from our sample that bacula less than 24.0 mg. in weight or less than 10.2 mm. in length must belong to juveniles. The minimum sizes for recognizable adult bacula would be 28.5 milligrams and 10.8 millimeters. The overlap of a few individuals renders the process slightly unreliable as regards weight, and a little more so as regards measurements of length. A frequency distribution for bacula weights is shown in Fig. 2. To check the reliability of baculum weights for predicting the ages of squirrels, a point intermediate to the means of the juvenile and adult baculum weights was calculated. This "point of no preference" (Fig. 2) is that point at which the percentage of juveniles whose baculum weights exceed the point is equal to the percentage of adults whose baculum weights are less than the point. In this case, the point was found to be 25.75 milligrams. Since only three baculum weights overlap relative to this point, it would appear that less than 3 per cent of the squirrels comprising a similar sample might be misidentified if their ages were otherwise unknown. By the same method, less than 9 per cent of the squirrels would be aged incorrectly using baculum length.

Skull and Long-bone Dimensions

Five skull measurements were taken as listed in Table 1. Actual differences between the means of juvenile and adult measurements ranged from slight to about 3 millimeters, with skull length, zygomatic width, and cranial width differences all significantly higher in the adults. For all skull measurements, as well as for femur length and humerus length, overlap occurs between juvenile and adult values to such an extent that separation points are not clear-cut. Single measurements from individuals of unknown ages will not certify age unless by chance they exceed the maximum measurements for either group or fall short of the minimum measurements. As an example, any skull longer than 61.5 mm. can be assumed to be adult while one less than 55.5 mm. would be juvenile. Since many values will fall between the extremes rather than outside, age assignment from skull and long-bone dimensions is limited in useful-

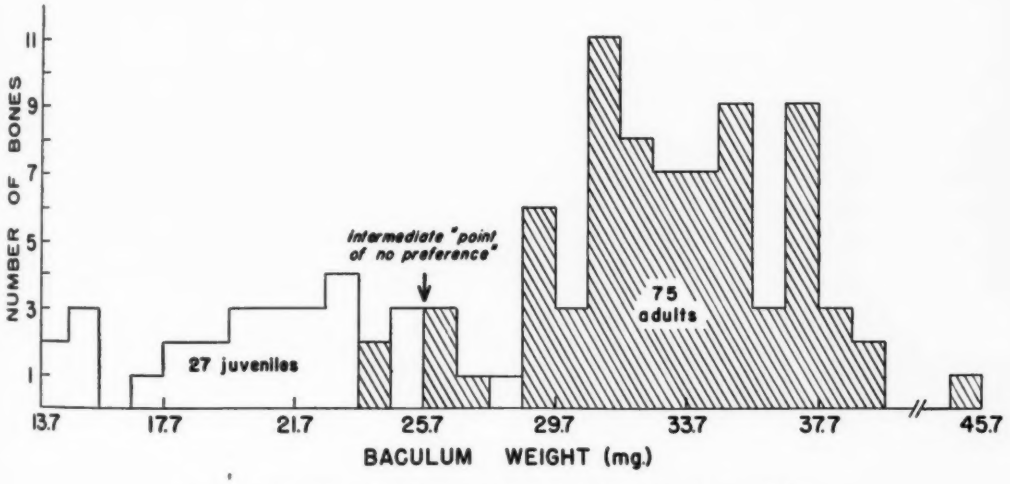

FIG. 2. Frequency distribution of gray squirrel baculum weights.

ness, and a part of the population would have to be aged by another method.

Cartilage Plate Condition

The condition of the cartilage plate between the epiphysis and diaphysis was studied by visual inspection of femora and humeri after they had been cleaned of all soft tissues and dried. The observations were made independently of other measurements and histological determinations to avoid any bias in judgment. Two classes were used in distinguishing the individuals, unossified and ossified.

In the unossified condition, both bones showed a distinct separation between epiphysis and diaphysis, which indicated the presence of cartilage. In the dried bone, the cartilage tends to shrink, resulting in a groove or notch which is visible and rough to the touch. A knife blade or even the fingernail is caught when scraped over the junction.

The ossified condition was characterized by the absence of a demarcation groove at the cartilage plate. The junction in some individuals, although dense and smooth, is revealed by a difference in coloration, often resulting in a more or less distinct line of lighter color than the surrounding bone; presumably this is an intermediate condition, although the uninterrupted surface indicates that complete ossification has occurred. In most bones of this class, the extent of the ossification completely obliterates the site of the cartilage plate.

The technique is essentially that described by Hale (*op. cit.*), who also applied it to fresh bones of cottontails (*Sylvilagus floridanus*) including those on intact animals. We made no systematic evaluation of this test on bones of intact squirrels, but similarities to cottontails suggest its usefulness. The accuracy of this test, if used in the field, may be expected to be slightly less than when using the baculum, but some accuracy may well be sacrificed for a more expedient field method.

When the cartilage plate conditions are correlated with ages, as determined by histology, the accuracy of using the cartilage plate for aging is suggested by Table 2. When the population sample consists of about 25 per cent juveniles, on the average, about 90 per cent of the squirrels of unknown ages can be correctly aged, since 89 per cent of unossified bones are from juveniles and 92 per cent of ossified bones are from adults. The comparison is of further interest for it reveals to some extent the degree of correlation between age in terms of sexual development and age in terms of physical growth. For the most part, sexually mature squirrels, which have been considered adults in this discussion, have attained full skeletal growth as shown by their ossified long bones; but a few functional adults apparently are still adding growth to the skeleton as the open cartilage indicates. On the other hand, a few squirrels with mature skeletons are slow to attain sexual maturity. These variations between sexual and physical maturity are undoubtedly paralleled in other mammals.

TABLE 2. — CONDITION OF CARTILAGE PLATE IN RELATION TO AGE IN MALE GRAY SQUIRRELS

Condition	Number	Percentage
Unossified	27	
Juveniles	24	89
Adults	3	11
Ossified	81	
Juveniles	6	7
Adults	75	92

SUMMARY

Based upon 108 male gray squirrels collected during all months, this paper reports a search for skeletal age criteria. Average skeletal dimensions and observations on the cartilage plate between the epiphysis and of squirrels as determined by reproductive histology.

With one exception, the mean of adult skeletal measurements exceeds that of juveniles; generally, the mean adult measurements are significantly greater. The overlap of individual measurements between the two age groups is extensive; hence, age prediction from single measurements of skeletal parts is limited at best, except perhaps in the case of the baculum.

The use of the baculum as an age criterion is discussed. An analysis of baculum weights is summarized showing that a reliable separation point exists between juveniles and

adults. Baculum lengths are slightly less accurate for aging.

A cruder and perhaps more expedient method of aging squirrels is offered by the cartilage plate between the epiphysis and diaphysis of leg bones. Investigators using this method can age about 90 per cent of the squirrels, since 89 per cent of unossified bones are from juveniles and 92 per cent of ossified bones are from adults.

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EDITORIAL NOTE

On page 376 of this issue, the Society's hard-working Committee on Nomenclature commends to us the standard procedure of listing sex ratios as the number of males per 100 females. *This is not the present recommendation of the Journal to its authors.* At least some of our present editorial board believe, quite to the contrary of our learned colleagues, that the older practice should be resolutely condemned. As honored as the traditional ratio is, its confidence limits are asymmetrical and seldom expressed. The result is an intellectual trap into which all but the most biometrically minded game managers are apt to fall. In a profession which is constantly collecting samples, sampling limits must be constantly borne in mind; and the precentage of males is a lot easier to handle mentally. With 50 per cent of one sex in an infinite population, it is simple to recall that, as a general rule (95 times out of 100), samples of 100 will lie within 10± per cent of this 50, samples of 1,000 within ±3 per cent, and samples of 3,000 within ± 1 per cent. This 10-3-1 series is easy to remember, and it has none of the awkwardness associated with similar limits attachable to males per 100 females, which for samples of 100 drawn as above would vary from 67 to 150 males per 100 females. The 1956-57 Committee on Nomenclature performed an herculean job for the Wildlife Society. On this one small point, however, it seems to us to have gone astray.—J.J.H.

BRIEFER ARTICLES

NUTRIENT COMPOSITION OF EARTHWORMS[1]

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Earthworms constitute an important food item for various species of migratory birds including the woodcock (*Philohela minor*), the Wilson's snipe (*Capella gallinago*), the robin (*Turdus migratorius*), and the starling (*Sturnus vulgaris*), and the U.S. Bureau of Biological Survey has identified earthworm fragments in stomach contents of 45 species of birds (Walton, 1928). In addition, earthworms have been reported to be important food items at various times for raccoon (*Procyon lotor*) and opossum (*Didelphis marsupialis*) as well as for shrews and moles (Dexter, 1951; Walton, *op. cit.*; Darwin, 1883).

Information regarding the nutritional value of earthworms was needed in planning woodcock feeding studies, but a literature search failed to reveal any data on this subject.

Earthworms (approximately a pint of each species) gathered from woodcock feeding grounds were delivered to the laboratory in the live, partially scoured condition. The *Lumbricus terrestris* measured 4–6 inches in length, *L. rubellus* 3 inches, and the very active *Eisenia rosea* (tentative classification) about 3 inches. The volume of each lot was estimated with a graduate cylinder. They were weighed, placed in porcelain evaporating dishes, killed by placing in an oven at 130°C. for 1 hour, dried over concentrated sulfuric acid in a vacuum desiccator at room temperature to constant weight, and then weighed and ground for analysis. Protein was determined by the Kjeldahl nitrogen procedure, ash by burning in a muffle furnace at 600°C. to constant weight, fat by ether extraction in a Soxhlet apparatus, and carbohydrate by difference. Energy was determined in an Emerson bomb calorimeter.

The results, shown in Tables 1 and 2, indicate that the three species are very high in protein content, containing from 53 to 64 per cent on the dry basis. They also contain good amounts of fat and energy. They are low in carbohydrates, however, and contain large amounts of ash. The latter is partly due to ingested particles of soil, although the worms had been scoured overnight in damp paper towels. On the fresh basis, as consumed by various wildlife species, a brief calculation shows that they contain about 83 per cent moisture, 8 to 9 per cent protein, 3 per cent carbohydrate, and 1 per cent fat.

[1] Authorized for publication on February 26, 1957 as Paper No. 2131 in the Journal Series of the Pennsylvania Agricultural Experiment Station and Paper No. 82 of the Pennsylvania Cooperative Wildlife Research Unit.

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Table 1.—Weight, Volume, and Dry-matter Content of Earthworm Samples

Species	Approx. Volume (ml.)	Fresh Weight (gm.)	Dry Weight (gm.)	Dry Matter (per cent)	Moisture (per cent)
L. terrestris	220	227.7	39.57	17.38	82.62
L. rubellus	265	258.7	42.18	16.30	83.69
E. rosea	260	247.0	40.47	16.38	83.61

Table 2.—Analysis of Earthworms (Dry-matter Basis)

Species	Protein (per cent)	Ash (per cent)	Fat (per cent)	Carbohydrate (per cent)	Energy (Cal./gm.)
L. terrestris	53.50	23.07	6.01	17.42	4.42
L. rubellus	63.69	15.06	4.77	16.48	4.70
E. rosea	61.38	15.67	4.39	18.56	4.73

HARMONY OR DISCORD? A CRITICAL LOOK AT WILDLIFE MANAGEMENT

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Most wildlifers are too involved with pheasants, deer, and other large animals to have much time for *Sorex*. Yet *Sorex*, one of our smallest mammals, is an example for wildlifers to ponder. *Sorex* is a dynamo, a go-getter, a creature with a goal before him and he devotes most of his life to that goal. He has been going so long he has become wedge-shaped, with a "forward look," and rushes near-sighted after his objective, oblivious to where he is, where he is going, and why he is going at all.

We wonder if most wildlifers are like *Sorex*. Are we each following our own noses, each narrowly specialized, each seeking a somewhat different goal, and most of us oblivious to where we fit into the scheme of things? If this is only partly true, are we getting the most from our efforts if they are only partly unified and we are not fully aware where we fit into the mosaic of human affairs? Perhaps it would pay to slow down, raise our noses from the narrow path, and take a look at the world about us.

Wildlife management is emerging from an era that put all its faith in laws, regulations, predator control, and game farms. In this period it was a narrow, specialized activity. Laws and regulations purported to govern the size of the harvest and the behaviour of harvesters, yet tended to ignore the factors controlling the production of the crop. Stock from game farms was set out wherever public demand required it or where superficial observation suggested it would live long enough to provide targets. Predator control was based on a simple mathematical approach that ignored the effects of time, reproduction, and the skill of the controller, all essential to any accurate formula.

The new look for wildlife management has brought with it the clear recognition that over large areas wildlife production is not controlled by wildlife technicians, administrators and legislators, but by foresters, farmers, city planners, engineers, and others who make use of the land from which wildlife is generally produced as a by-product. There are, of course, some areas where wildlife is an element of the unaltered wilderness, but even here, production and species composition fluctuate willy-nilly with advancing plant succession, weather, and the natural degeneration of climax vegetation.

The forester, the farmer, and the engineer have their tools and are using them to make visible and frequently vast alterations to the land in achieving their ends. The harvest of a predetermined volume of pulpwood or saw logs by means of powerful, mechanical equipment from an area on which production has been closely estimated can, in a short time, erase a wildlife crop and clear the way for a new one. The engineer with his relatively precise procedures can, through the judicious location of a dam, wipe out, greatly modify, or create a productive waterfowl and muskrat marsh. The farmer, more mechanized every year, soon sees economy in large fields, free of fences, where mechanical equipment can be used with greatest efficiency. What will be his choice as a producer of hybrid corn or soybeans in considering removal of weeds and shrubs at the roadside to make way for a few more rows of crop? Will dollars be more attractive than a brood of pheasants or quail, a few cottontails or a catbird's song? His choice is simple if he is not a hunter or a naturalist. A few passes with his machine, and he has his additional crop area. On the other hand, the farmer, while unknowingly destroying the original crop of deer and wild turkey, may create an environment for cottontails, pheasants, Hungarian partridge, European hare, and starlings. Continually modifying the land and its vegetation, he is a prime influence upon the quality and composition of wildlife populations.

Where is the wildlife manager in this picture and what tools has he brought with him? It seems that he arrived on the scene almost empty-handed. He divided his time among inventory, reconnaissance, research, and a search for tools, or fell back on the outdated tools when emergency demanded visible action. His dilemma lies in the fact that rarely does he manage the land on which his crop is produced. Usually his problem is to find ways of integrating wildlife management with other land-use practices, and in his search he is inevitably brought into contact with others using the land. There is no question whether wildlife managers should integrate their activities with the other users of the land. They must. A more urgent question is what others have to gain from integration with wildlife management.

Within the so-called conservation movement we hear much of wise land use, but the cooperation between users so necessary to the determination of what constitutes wise use is not so evident. Who is to say which is the sounder use, to harvest the standing timber from an area, preserve it in a recreational park, or leave it inviolate to protect a city's water supply? What economic or ethical compensation can be paid the farmer to encourage him to leave an uncropped strip at the field border next to his fence? To what degree are forest and wildlife management compatible upon the same piece of land? Today a good deal of single-purpose utilization is seen on the land. Excessive urbaniza-

tion and industrial development at the expense of parks and recreational areas, and harvest of wood products without reference to sound silvicultural principles, water control and recreation, are several of many possible examples.

Rarely is our field allowed to be single purpose. Wildlife management must usually carry on in a multiple-use program in which the tools of other land users are used to gain its ends. Bulldozers, power saws, draglines, dams and other water-control structures, as well as ploughs and seeders, may be employed for a multiple purpose on the same piece of land. The judicious use of a bulldozer building an access road may, within a few minutes, create clearings for broods of grouse. A pond strategically located to water stock may support a few ducks, muskrats, and other wildlife, provide a pleasant recreation ground and possibly a supply of pan fish as well as water for fire control. A little planning in a reforestation project on abandoned farms may lead to better wildlife habitat with little or no alteration in the forester's objectives. A row or two of corn left at the field border may be the key to a covey of quail, a flock of doves, or a share of pheasant hunting on land that might otherwise produce only corn.

Current conceptions of good land use, in addition to including such aspects as sustained yield and the greatest good for the greatest number, carry with them the connotation of a high degree of ethical concern for the needs of man in the future, and assume that benefits to man are spiritual and social as well as economic. Wildlife is largely a recreational resource utilized for the enrichment and restoration of mind and body. Although economics enters as a by-product, it would be difficult to argue that economics is the only or even the main reason for management. Nevertheless, money is a major consideration in a multiple-use program. That a purely economic approach is untenable is now being demonstrated in many areas where government agencies responsible for resources management are being forced into what some people believe to be economically unsound programs. There are increasing numbers of cases where social and aesthetic conditions outweigh monetary considerations. Responsible agencies are being forced to adopt programs simply because a large number of people want them. On these areas best use for the greatest number of people has become recreational use.

The public has made these judgments, some sound, some not. No doubt, as in the past, we will continue to make some wrong decisions, and valuable resources will be wasted by a misguided or uninformed people. To determine what is best use, sociologists, economists, ecologists, must work together to assess the social, philosophical, economic, and biological values of land utilization, and advise the people accordingly. Only on such a basis will good land use be taken out of books onto the land.

Wildlife management is still and always will be a specialty, but to succeed it must take a broad view of its own objectives and recognize social, economic, and biological factors in its own and related fields. A view limited to the ecology of game and fur species is too narrow to lead to successful management. Big-game management divorced from forest economics is not realistic. Constant emphasis on more waterfowl without consideration of crop damage is unreasonable. Concentration of management effort on game and fur when thousands are beginning to visit parks and to use the outdoors generally, simply to see the living world, is short-sighted. These, and a huge potential army of outdoor users yet to come, want to have the world of nature, not just of game and fur, interpreted to them.

What will be the demand for wildlife in ten, twenty years from now? Will we still be thinking mainly of hunters or will other uses of wildlife be developed to a higher degree and by more people than at present? Certainly this is the trend. Will we still be pointing with pride to a few thousand yards of multiflora hedge or a few acres of deer browse regenerating in the path of a bulldozer while other men punch holes in mountains to drain rivers of their kilowatts, erect skyscraping, low-cost apartment houses, or make the Great Lakes accessible to ocean liners? Will we be of stature sufficient to meet the requirement for guiding the public in the mass onslaught on recreational areas that is bound to come with the development of automation, increased earnings and decreased working hours? Will we be able to convert our present talk about the need for controlled distribution of hunters into successful action programs? Where will wildlife management be with increased mechanization and intensification of agriculture and forest management?

It is a healthy program that knows where it is going, and why. In the wildlife field, the "why" of our going is more evident than the "where." We exist to guide the people, our services not necessarily being confined to the wishes of vociferous minorities. Our goal, our "where," is perhaps using our knowledge, biological and otherwise, to provide wildlife where it is wanted, and in desired abundance, within the limits imposed by other uses of the land. If there were no wildlife management, there would still be wildlife, and it would also be used. The measure of our success, therefore, is the degree to which our efforts narrow the gap between what people now and in the future would get without us, and what they want and need.

Our biological and ecological knowledge of wildlife is not enough to achieve this goal. The land is complex and its uses interrelated. Like notes in music, the skills for using land can come together in harmony or discord. Harmony demands cooperation, coordination, and a knowledge of more than one key.

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SHAD CATCHES AND WATER TEMPERATURES IN VIRGINIA[1]

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The relationship of shad (*Alosa sapidissima*) runs and water temperatures has long been recognized. Although general statements concerning this relationship are present in the literature, some are contradictory and few are supported by specific evidence. Leach (1925) stated that the main body of shad arrived at the river mouths when water temperatures were 56° to 66°F., while Bigelow and Schroeder (1953) said that shad enter streams from the Gulf of Maine when the water has warmed to 50° or 55°F. Talbot (1954) indicated that shad runs in the Hudson River usually start about the first of April, when the water temperature is about 40°F., and the peak of the run occurs between the middle of April and the middle of May when average water temperatures are 45° to 57°F.

The role of temperature in controlling the movements of fishes other than shad has been described by Huntsman (1936), who found in the Margaree River, Nova Scotia, that a late salmon (*Salmo salar*) run corresponded with delayed warming of river water. Mottley (1938) working in Paul Lake, British Columbia, concluded that temperature acted both directly and indirectly in influencing the spawning time of rainbow trout (*Salmo gairdneri kamloops*). Sullivan (1954) reviewed much of the work regarding the effects of temperature on the movements and distribution of fishes.

[1] Contribution from the Virginia Fisheries Laboratory No. 72.

To investigate the possible effect of water temperatures on shad catches, records of catches and temperatures for 1953, 1954, 1955, and 1956 have been examined from the York River, a tributary of Chesapeake Bay located 25 miles northwest of the Virginia Capes.

Water temperature records were obtained with a Foxboro thermograph located at the end of the Virginia Fisheries Laboratory pier at Gloucester Point 6 miles upriver from the mouth of the York River. The mean depth of the sensitive element of the thermograph was about four feet below the surface. Since the York River water is essentially isothermal during spring, these temperatures are considered to be representative for the region of the river traversed by shad. The daily temperatures were taken as the mean of the maximum and minimum points on the thermograph, and the weekly averages represent the mean of the seven daily values.

Fishermen capture shad in the York River with stake gill nets. These nets, 20 by 15 feet respectively in average length and depth, are usually set in series of from 10 to 40. Records of the numbers of nets fished daily and the numbers of shad captured were kept each year from 1953 to 1956 by a group of 15 to 23 shad fishermen who set their nets within 20 miles upriver from Gloucester Point. Daily catches were averaged to obtain a mean catch-per-unit-of-effort for each week. Comparable weeks during the

TABLE 1.—MEAN WEEKLY WATER TEMPERATURES AND MEAN WEEKLY SHAD CATCHES BY STAKE GILL-NET FISHERMEN IN THE YORK RIVER

Year	1953[1]		1954[2]		1955[3]		1956[4]	
Week Number	Temp. °F	Shad Catch per Net Day	Temp. °F	Shad Catch per Net Day	Temp. °F	Shad Catch per Net Day	Temp. °F	Shad Catch per Net Day
1	44.8	0.135	41.0	0.006	37.1	0.125	37.1	0.004
2	44.9	0.158	41.0	0.056	38.9	0.000	39.6	0.062
3	44.7	0.282	44.5	0.133	38.5	0.007	42.8	0.350
4	46.9	0.407	46.1	0.285	41.5	0.113	43.0	0.210
5	44.6	0.332	47.1	0.315	46.4	0.203	43.8	0.404
6	46.2	0.479	47.5	0.608	48.3	0.412	46.4	0.594
7	51.3	0.720	47.4	0.793	51.7	0.638	47.3	0.722
8	53.0	0.585	49.7	0.862	51.2	0.724	45.0	0.712
9	52.9	0.629	53.4	0.731	49.3	0.726	44.8	0.972
10	57.5	0.511	55.9	0.580	52.1	0.617	50.4	1.292
11	56.9	0.369	60.0	0.653	58.1	0.417	49.6	0.953
12	56.3	0.319	64.4	0.455	61.4	0.301	51.5	0.865
13	60.7	0.281	67.5	0.366	61.7	0.227	53.0	0.786
14	66.6	0.199	67.3	0.408	65.6	0.350	58.5	0.736
15	72.1	0.222	—	—	67.2	0.209	61.4	0.778
16	—	—	—	—	—	—	64.9	0.497

[1] First week began February 1.
[2] First week began January 31.
[3] First week began January 30.
[4] First week began January 29.

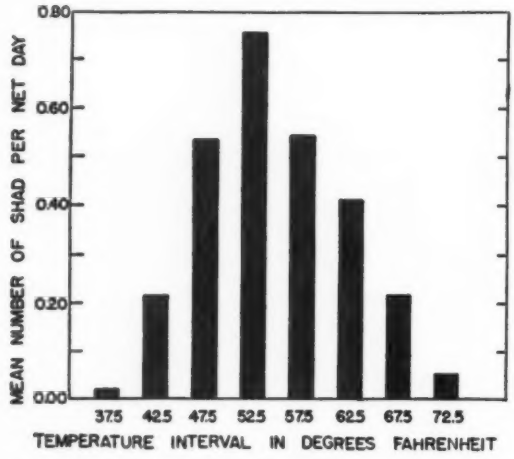

FIG. 1. The average shad catch at different water temperatures by stake gill-net fishermen in the York River, Virginia, in 1953, 1954, 1955. and 1956. The temperatures indicated are midpoints of five-degree intervals.

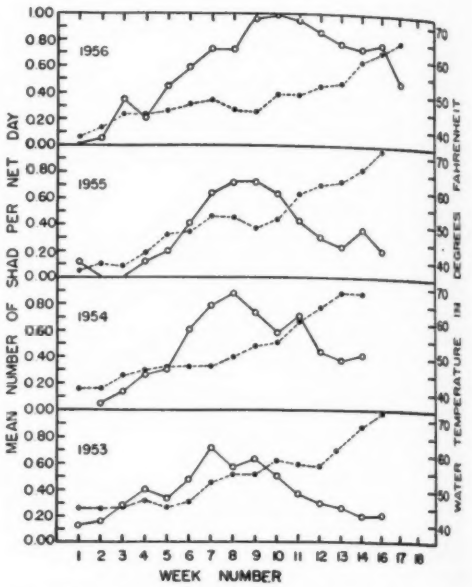
1956
1955
1954
1953
MEAN NUMBER OF SHAD PER NET DAY
WATER TEMPERATURE IN DEGREES FAHRENHEIT
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18
WEEK NUMBER

FIG. 2. Mean weekly water temperatures and mean weekly shad catches by stake gill-net fishermen in the York River, Virginia. Solid line, shad catch per net day; broken line, water temperature.

four fishing seasons were numbered consecutively, the first week in 1953 beginning on February 1, in 1954 on January 31, in 1955 on January 30, and in 1956 on January 29.

Mean water temperatures and catches for each weekly period are summarized in Table 1 and mean catches for the four-year period at different water-temperature levels are illustrated in Fig. 1. Below a water temperature of 40°F., almost no shad were caught. Between 40° and 45°F., a few were taken, but largest catches were made in water of 45° to 59°F. At higher water temperatures, catches tapered off, but even at 70° to 74°F. more shad were caught than at 39°F., or less. Low water temperatures appear to be a limiting factor on early spring catches; the effect of high temperatures, however, is not clear cut.

Water temperatures and relative availability of shad plotted by weeks for each year (Fig. 2) suggest that catches are most concentrated in years when the temperature gradients are steepest. The peak catches appear to have been made a week later each year since 1953. Variations from the average are apparent. Obviously any relationship between shad catches and water temperatures is not simple and may not be direct. It is well known among fishermen that factors other than temperature also affect their catches. Wind, wave action, and turbidity appear to increase catches by concealing the nets, while crabs, menhaden, jellyfish, seaweed, and other debris decrease catches by clogging the nets. Factors at sea that may influence the timing and pattern of the spring migration are obviously beyond the influence of local water temperatures.

Further information on the relationship between shad catches and water temperatures is desirable. A knowledge of this relationship should be helpful to shad fishermen, who now set their nets very early in the fishing season so that the first large shad runs will not be missed, and consequently often exert considerable effort with little reward.

SUMMARY

A study of the relationship of water temperature and shad catches in the York River for the years 1953–56 showed that greatest catches-per-unit-effort were made at water temperatures of 45° to 59°F. Below a water temperature of 40°F. almost no shad were caught.

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THE WILDLIFE SOCIETY

Report of the Executive Secretary for the Year 1956–57

Membership

With a uniform $6 annual dues rate in effect for the first time, The Wildlife Society, in its twentieth year of existence, maintained its combined number of members and subscribers at the 3,000 level. At the end of December, 1956, we had 2,975 members and subscribers, including 235 new members and 50 new subscribers; however, 306 members and subscribers in 1955 failed to renew in 1956 compared with 221 who failed to renew the previous year, and 239 the year before that. Probably this is, in part, a result of the one dollar increase although, currently, we have 237 new 1957 members and subscribers, and should have no difficulty in exceeding a combined total of more than 3,000 by December, 1957. Deaths of the following members are reported with regret: F. A. Bryant, Nathan Fellows, Lawrence E. Hicks, Charles H. Hopkins, Robert L. Patterson, and Kenneth A. Reid.

Memberships are shown in Table 1.

Publications and Editorial Affairs

With the publication of the July, 1956 issue of The Journal of Wildlife Management, Dr. Oliver H. Hewitt concluded his term as Editor and was succeeded by Dr. Joseph J. Hickey. Dr. Hewitt had served as Editor since April, 1953 and, before that, had been Associate Editor with Dr. Gustav A. Swanson. Upon the advice of the Council the number of Associate Editors was increased and now a board of 16 specialists in big game, biometry and census techniques, fish and aquatic biology, furbearers and predators, general management, pathology and parasitology, upland game, and waterfowl assist the Editor. Tom Evans continues as Editor of The Wildlife Society News.

Following the appointment of the new Editor, and faced with increased printing costs at Cayuga Press, it appeared desirable to change publishers. This was done in August at considerable expense ($989.50) for packing, crating, transporting, trip insurance, unpacking, sorting, inventorying, and storing of back issues, symposia, and indexes at the new printers (The Allen Press, Lawrence, Kansas) but, with the reduced printing rate now in effect, the move was justified. The first Wildlife Society publications to be printed by The Allen Press were The Wildlife Society News No. 58 for August and the October, 1956 issue of the Journal.

By indicating on the return dues-notice envelope the availability of symposia and indexes, a considerable increase in the sale of the Animal Cycle and Farm Pond Symposia and the first ten-year index was realized during the fall and winter with 203, 135, and 114, respectively, being sold. Sales of back and single issues of the Journal amounted to about $790. Fourteen issues of the Journal are out of print entirely and the supply of eight other issues is nearly exhausted.

One set of the Journal was purchased during the year, and this set, together with one obtained last year, is being bound for Society records and use.

The Second Ten-year Index Committee made good progress and it is expected that this Index will be completed and published this year.

Table 1.—Membership in the Wildlife Society

Class of Membership	Number of Paid-up Members as of Close of December				
	1952	1953	1954	1955	1956
Honorary	11	13	15	17	18
Life	10	10	17	27	31
Regular	1,919	2,140	2,346	2,503	2,485
Subscribers	388	377	406	429	441
Total	2,328	2,540	2,784	2,976	2,975

An article, "The Wildlife Society," by the Executive Secretary was published in the *Journal of Forestry*, 54(12):821–823, as one of a series of articles dealing with scientific societies and organizations of potential interest to foresters. Reprints of this article, which describes the founding, organization, objectives and activities of The Wildlife Society, were obtained for use in answering questions about the organization and as an aid in acquainting potential members with the Society.

Affiliations and Representation at Meetings

The Society maintained its affiliations with and/or named official representatives to the International Union of Conservation (formerly IUPN), the Natural Resources Council of America, the National Watershed Congress, the International Science Foundation, the National Research Council, the American Association for the Advancement of Science, and the American Committee for International Wild Life Protection.

Edward H. Graham and Lloyd W. Swift served as official representatives of the Society at the General Assembly of the IUC held in Edinburgh, Scotland, June 20–28, 1956. Your Secretary and C. R. Gutermuth represented the Society at meetings of the Natural Resources Council of America. M. S. McMurtrey was a delegate to the Third National Watershed Congress held at Lincoln, Nebraska. Frederick H. Dale was appointed representative to the National Research Council and George A. Petrides to the American Committee for International Wild Life Protection.

John M. Anderson, of the Winous Point Club, Port Clinton, Ohio, continued as the Society representative to the Waterfowl Advisory Committee, attending the meeting held in Washington, D.C., in August.

The Council of the AAAS, at its December 27, 1956 meeting, voted to change the status of societies such as The Wildlife Society, which has been listed as an associate, to that of affiliate with the privilege of representation on the AAAS Council.

David E. Davis was appointed by President Allen to represent The Wildlife Society at a meeting of conservationists and ornithologists to discuss the conservation of the whooping crane. This meeting, attended by United States and Canadian Federal officials, state fish and game personnel, and private individuals, was held in Washington, D.C., October 29.

Elections and Bylaws Revisions

Nominees for Regional Representatives for 1957–58 were as follows: Region I, Roger Latham and W. R. DeGarmo; Region II, E. B. Chamberlain and C. Edward Carlson; Region III, Bill T. Crawford and Don Douglass; Region IV, Lee E. Yeager and Don C. Quimby; Region V, Fred M. Baumgartner and W. C. Glazener; Region VI, Charles F. Yocom and J. B. Lauckhart; and Region VII, R. Y. Edwards and C. David Fowle. The Nominating Committee, under the Chairmanship of Hayden W. Olds, nominated A. Starker Leopold and W. Winston Mair for President, and Richard B. Miller and Ben Glading for Vice-President. The election ballots were counted and audited as prescribed by the Bylaws and the winning candidates were those named first in each of the offices listed above.

All the Bylaws revisions put to vote passed with a large majority. The revisions (1) change the title of Secretary-Treasurer to Executive Secretary, (2) delete the Executive Secretary as a voting member of the Council, (3) enlarge upon Article IX so that the procedures governing the formation and regulation of Society Sections are given in some detail, and (4) make it possible to amend the Bylaws at any regular or special meeting of the Society if advance notice of the proposed changes is contained in the notice of the meeting, provided only, however, that any member unable to attend a meeting may request the Executive Secretary in writing before such meeting to register a vote for him either for or against the amendment in question and such votes shall be counted with the votes of the members present.

Activities of the Society Sections

All Sections of the Society were active during the year. The California Section held its annual meeting in San Luis Obispo on the campus of California State Polytechnic College, December 17 and 18. The President and Vice-President of this Section for 1957 are Dr. Raymond F. Dasmann and Charles K. Fisher, Jr., respectively.

The Central Mountains and Plains Section

reported that, as of February 23, 1957, Harold Steinhoff, Robert Ballou, and Harvey Miller succeeded Ralph R. Hill, Harold Steinhoff, and Jack Grieb as President, Vice-President, and Secretary, respectively. The Section held a meeting at the Cameron Pass 4-H Club Camp, August 13–14, with representatives from each of the states making up the Section in attendance.

The Minnesota Section held meetings on November 29 and January 10. Its officers are: President—Charles Burrows; Vice-President—Ross Hanson; and Secretary-Treasurer—Clair T. Rollings.

The Northeast Section was co-sponsor of the Northeast Conference held January 7 and 8 at New Haven, Connecticut. The Northwest Section held its annual meeting December 27 and 28 on the campus of the University of Washington in conjunction with the Northwest Scientific Association. James Hatter, Stanley Guenther and Don Robinson succeeded Paul D. Dalke, Raleigh Moreland, and Kenneth Hungerford as President, Vice-President, and Secretary-Treasurer, respectively.

The Southeast Section held its annual meeting in conjunction with the Tenth Annual Conference of the Southeastern Association of Game and Fish Commissioners at Little Rock, Arkansas, October 7–10, 1956. New officers elected were Frank Barick, President; and Chester Phelps, Vice-President. Leslie Glasgow was re-elected Secretary-Treasurer.

Other Activities

Among the Members coming to the attention of your Secretary as having received fellowships or grants for overseas research were Dr. Victor B. Scheffer (National Science Foundation Grant) for research on marine mammals, Cambridge University, England; Drs. Helmut K. Buechner, George A. Petrides, and Wendell G. Swank (Fulbright Awards) for big-game research in

TABLE 2.—FINANCIAL REPORT

ASSETS				
Cash				
Checking account (Bank of Silver Spring, Md.)			$12,776.74	
Savings account (Bank of Silver Spring, Md.)			4,284.85	
Permanent fund (Emigrant Ind. Savings Bk., N.Y.)			11,117.11	
Permanent fund (Perpetual Bldg. Assn., S.S., Md.)			1,799.72	$29,978.42
Securities				
44 shares State Street Investment Corp.			1,760.00	
31* shares Loomis-Sayles Mutual Fund, Inc.			1,295.80	
U. S. Government Bonds Series G—12 yr. Bonds				
Serial No.	Cost	Date of Purchase		
D-2576621G	$500.00	April, 1947	488.00	
D-2576622G	500.00	April, 1947	488.00	
D-2943626G	500.00	Sept., 1948	483.50	
D-2943627G	500.00	Sept., 1948	483.50	4,998.80
Accounts receivable			219.00	219.00
Total assets				$35,196.22
LIABILITIES				
Liabilities				None
Net worth**				$35,196.22
Total liabilities and net worth				$35,196.22

* One 1956 capital-gain share ($41.80) declared on October 8, 1956. This share received in lieu of cash dividend, giving us 31 shares instead of 30 held in 1955.

** Excludes back issues, reprints of symposia and indexes, of indefinite value.

TABLE 3.—STATEMENT OF RECEIPTS AND DISBURSEMENTS

Bank balance February 25, 1956			$26,534.10
Receipts (deposited to checking account)			
Dues	$15,176.22		
Subscriptions	2,963.95		
Sales:			
Back issues, single issues, JOURNAL	789.65		
Animal cycle symposium	203.25		
Farm pond symposium	135.00		
Ten-year index	114.00		
Membership list	1.00		
Over-runs: Special articles, JOURNAL	300.20		
Refund on canceled insurance due to move	204.15	$19,887.42	
Receipts (deposited to savings account)			
Dividends and interest	771.57		
Life membership dues	1,425.00	2,196.57	22,083.99
			$48,618.09
Disbursements			
Publications:			
JOURNAL, printing	$11,229.53		
NEWS, printing (five issues)	682.10		
Purchase of set of JOURNAL for Society use	100.00		
Purchase of reprints of article on Society	14.42		
Maint. of stencils, postage, and mailing of publications	1,283.75		
Move of back issues from Cayuga Press to Allen Press inc. frt., trip ins., packing, unpacking, stacking, and taking inventory	989.50		
Insurance, 3-year fire and extended coverage	390.04*	$14,689.34	
Editor's Expenses:			
Miscellaneous (postage, stationery, etc.)	248.30		
Editorial assistance	186.75	435.05	
Executive Secretary:			
Clerical assistance	700.00		
Honorarium	700.00		
Travel and meeting expense	3.65		
Fidelity bond (3-year coverage)	156.25	1,559.90	
General supplies, printing, and communications, inc. ballots, dues notices, etc.	1,288.23		
Refunds, bank charges, bad checks	82.36		
Affiliation dues (I.U.C.N.R., Natl. Res. Council)	100.00		
Meeting exp. (awards, delegates, employment desk)	144.79		
Audit, 1955–56 accounts	30.00		
Leopold medals (10)	260.00		
Index committee (preparation 2nd 10-year index)	50.00	1,955.38	18,639.67
Bank balance February 23, 1957**			$29,978.42

* Total includes refund of $204.15, following move to Allen Press, reducing insurance costs to $185.89. Sprinkler coverage unnecessary at Allen Press.

** Books closed February 23, 1957 to permit auditing before annual meeting.

Africa; Dr. Walter E. Howard (National Science Foundation Grant) for a study of soil fertility–rodent relations, New Zealand; and Dr. William H. Elder (Guggenheim Foundation, Yale Bishop Museum, and International Society for the Protection of Birds) for ecological study of the nene goose, Hawaii.

Although the change of printers and move of back issues resulted in some delays in processing orders and mailing publications, 41 press orders and a like number of bank deposits were made during the year. The routine duties of the Secretary and his assistant, including the making of hundreds of address changes, processing new memberships and subscriptions, handling dues payments, sending invoices to subscribers, distributing membership application blanks, working with Society committees, general correspondence, and answering requests for information on professional opportunities and training required in excess of 1,000 hours of "homework."

Financial Report

In presenting the financial statement (Tables 2 and 3) of The Wildlife Society for the fiscal year 1956–57, it should be pointed out that the books were closed February 23, 1957 in order to permit an audit prior to the Annual Meeting. You are reminded, also, that a Fidelity Bond (Policy No. 90–464068) for the position of Executive Secretary, in the amount of $25,000 is in force for a 3-year period with the Maryland Casualty Company. The stock of Journals, symposia, and 10-year indexes held at The Allen Press is insured in the amount of $15,000 fire and extended coverage by policy No. 134379 with The Charlton Insurance Agency, Lawrence, Kansas.

Respectfully submitted,

DANIEL L. LEEDY,
Executive Secretary

REPORT ON THE WILDLIFE SOCIETY COUNCIL MEETING, MARCH 3, 1957

The Council met at 7:30 P.M. March 3, in the Statler Hotel, Washington, D.C. Members present were Durward L. Allen, President; John S. Gottschalk, Vice-President; Justin W. Leonard, Past President; and W. R. DeGarmo (alternate to Roger Latham), E. B. Chamberlain, Bill T. Crawford, Lee E. Yeager, A. Starker Leopold, and Ian McT. Cowan, Representatives of Regions 1, 2, 3, 4, 6 and 7, respectively. Region 5 was not represented. Editors J. J. Hickey and Thomas R. Evans, and the Executive Secretary attended as advisors.

The Council considered and approved, for presentation to the Members in attendance at the annual business meeting, nine resolutions mostly concerned with pending legislation.

Much of the five-hour Council meeting was devoted to a consideration of publication and budgetary affairs. In reporting to the Council, Editor Hickey pointed out that, although the 1956 volume of the JOURNAL had less pages than some of the preceding volumes, it contained more articles—this situation being due primarily to changes in make-up (wider type beds and more lines per page) inaugurated by Editor Hewitt last April. He stated, also, that the number of manuscripts received by the Editor had generally declined since 1953 and that the backlog of manuscripts now on hand is relatively low, which means a shorter period between date of receipt and date of publication. He reported that while enlargement of the Editorial Board to include 16 Associate Editors had spread responsibility for acceptance of manuscripts, the Editor's position required an estimated 1,200 hours per year. He recommended that an *ad hoc* Editorial Advisory Committee be appointed to study the feasibility of further splitting up the editorial duties. The switch from Cayuga Press to Allen Press, which was made last summer, resulted in a 34.5 per cent saving in printing rate for the JOURNAL but somewhat higher rates for issuing the NEWS, handling back-issue orders and maintenance of mailing stencils. The over-all savings, however, make it possible to provide some editorial assistance to the Editor, freeing him for the time-consuming job of analyzing manuscripts and making constructive suggestions to authors.

The Council ruled that the Editorial Board might accept papers longer than 20 printed pages when (1) these jeopardize neither the backlog of manuscripts nor the JOURNAL budget, (2) they can be used to fill out the size of issues our Members have

come to expect, and (3) they have been accepted by two members of the Board. The Council also ruled that papers from nonmembers of the Society might be accepted at the discretion of the Board without approval of the President. The Editor also was authorized to quote a rate for subsidized papers that would include both printing and editorial costs.

To carry on the activities of the Society during 1957–58, the following budget was approved with the understanding that up to $500 of income from the previous year's operations might be used, if necessary, to meet expenditures:

Publications	
JOURNAL, printing	$11,000
NEWS, printing	550
Maintenance of stencils, postage, mailing of publications, storage, etc.	1,800
Binding 2 sets of JOURNAL for Society	120
Purchase of Bylaws, membership lists	150
Editor's expenses	
Miscellaneous supplies, postage, etc.	400
Editorial assistance	1,200
Executive Secretary	
Clerical assistance	1,000
Honorarium	700
Travel and meeting expenses	200
General supplies, printing, and communications, including postage, mailing of ballots, dues notices, etc.	1,400
Meeting expenses (delegates, awards, employment desk)	150
Miscellaneous charges (audit, refunds, bad checks)	150
Affiliations	100
Contingency fund	580
Total	$19,500

The Executive Secretary also was authorized to set up a revolving fund of $3,000 for use in publishing the second ten-year index, a preliminary run of the WILDLIFE TECHNIQUES MANUAL, and a leaflet on training and employment opportunities.

Dr. Gustav A. Swanson reported on the activities of the Committee on WILDLIFE MONOGRAPHS and on a handbook of wildlife writing by Werner O. Nagel which is being considered as a special Society publication. The Council approved the initiation of a WILDLIFE MONOGRAPH series of publications to include bulletins on both fish and wildlife and which are to appear on an irregular basis as finances and the availability of manuscripts permit. It was recommended that such publications be edited by a separate Editorial Board, that they be financed from contributed funds or grants, and that they be issued free to all Members and subscribers. Dr. Leonard suggested that conservation agencies and institutions be advised of the new series as a potential publication outlet for longer works.

Mr. Nagel's handbook on wildlife writing received favorable comment from the Committee members who had read it, but the Council members requested the opportunity of reading it before approving it for publication by the Society.

Among other special publications discussed were: (1) the second ten-year index, which is expected to be completed within the year; (2) the WILDLIFE TECHNIQUES MANUAL, which may be duplicated in draft form for criticism and review; and (3) the leaflet on training and employment opportunities, which is being prepared by the Employment Committee. These publications, it was recommended, should be paid for out of a revolving publications fund and sold.

NEWS Editor Evans was commended for the good job he is doing with the NEWS, and was authorized to use, in the NEWS, photographs of the candidates for President and Vice-President in connection with Society elections.

Dr. Leonard reported on the work of an *ad hoc* committee which has considered ways of memorializing the late R. W. Eschmeyer. The following resolution was approved by the Council:

Whereas: the contributions of Reuben William Eschmeyer to the development of the field of fishery biology and management were so outstanding,

Be It Resolved: that The Wildlife Society establish a Publications Reserve Fund, to be known as the R. W. Eschmeyer Memorial Fund, and to be used to assist in the publication, in WILDLIFE MONOGRAPHS or other suitable publications, of outstanding papers in fishery biology or management.

That the publications thus aided carry the designation "Assistance in publication received from the R. W. Eschmeyer Memorial Fund."

That the fund be collected through solicitation of Society Members and other friends of R. W. Eschmeyer and that a committee of five Members be appointed by the President to conduct the solicitation for funds, which funds shall then be administered at the discretion of the Council.

Continued affiliation, with dues payments to the Natural Resources Council of America and the International Union for Conservation, was approved. C. R. Gutermuth was reappointed as Trustee and J. J. Hickey and Daniel L. Leedy were retained as Editor and Executive Secretary, respectively. No new Honorary Members were recommended this year.

The Secretary was instructed to write to Section Officers relative to the provisions called for in Article IX of the recently revised Bylaws. Most Section bylaws will require revision to conform with these provisions. A resolution from the Central Mountains and Plains Section urging the adoption of student membership rates in the Society was tabled.

The meeting was adjourned at 12:30 A.M.

Respectfully submitted,
DANIEL L. LEEDY,
Executive Secretary

MINUTES OF THE ANNUAL MEETING, MARCH 4, 1957

The twenty-first annual business meeting of The Wildlife Society was held March 4, 1957, at the Hotel Statler, Washington, D.C. Approximately 175 Members met in the Congressional Room immediately following the Society's Annual Dinner, which was attended by more than 100 Members and friends and at which the Society's Publication and Conservation Education Awards were presented.

President Durward L. Allen called the meeting to order shortly after 8:00 P.M. Minutes of the previous meeting were approved as published in the JOURNAL OF WILDLIFE MANAGEMENT, 20(3):338–340.

The Executive Secretary then gave a brief report of his activities during the year, referring the Members to a mimeographed report available in the meeting room for details on membership, income and disbursement, and other Society affairs.

The report of the Council Meeting held the preceding night was read by the Executive Secretary. Following comments by President Allen, the budget for 1957–58 and a new publication series, to be called WILDLIFE MONOGRAPHS, were approved. Efforts made during the year to obtain a grant of $100,000 for financing Society publications were discussed. Trustee C. R. Gutermuth commended President Allen for his attempts to obtain such a grant and urge President-Elect A. Starker Leopold to file additional applications.

Seven resolutions were approved including: (1) the commending of the Secretary of the Interior for his leadership in proposing amendments to the Coordination Act (60 Stat. 1080) for the purpose of providing adequate planning for, and full development of, fish and wildlife resources in connection with water-development projects constructed by federal agencies, by nonfederal agencies under federal license, or by nonfederal agencies with federal financial or technical assistance; (2) the request that the Agricultural Act of 1956, which includes wildlife conservation as a specific purpose of the Soil Bank Program, be amended to strengthen and implement those provisions that deal with wildlife development and management; (3) the endorsement of H.R. 783, a bill to authorize the U.S. Fish and Wildlife Service to undertake continuing research on the effects on fish and wildlife of chemical insecticides, herbicides, and fungicides, and the development of safe methods and rates of application of such pesticides, and also urging that other federal agencies and appropriate state agencies initiate studies or increase the emphasis on present studies in this field; (4) the urging that Congress enact H.R. 1058, a bill to establish a national wildlife refuge of at least one

thousand acres in area within the present range of the Key deer, *Odocoileus virginianus clavium*; (5) a resolution urging Congress to appropriate not less than two million dollars annually to the Forest Service, U.S. Department of Agriculture, for the improvement and management of wildlife habitat, including fishing waters, within the national forests; (6) an endorsement of H.R. 627 and S. 557 which, as introduced, would require Congressional approval of military withdrawals or reservations from the public lands in excess of 5,000 acres, require compliance on military areas with state or territorial game and fish laws, and encourage such multiple uses of military lands as are consistent with national security and military needs; and (7) an expression of appreciation to The Wildlife Management Institute, to members of the program committee of the 22nd North American Wildlife Conference, and to the Statler Hotel in Washington, D.C., for cooperation, facilities, and courtesies that contributed to the success of the Society's annual meeting.

The winners of the Society's Publication and Conservation Education Awards were reannounced for the benefit of Members not present at the Annual Dinner and abbreviated reports of these Awards Committees were presented. Farley Tubbs, Chairman of the Conservation Education Awards Committee, recommended that, in the future, consideration be given to granting awards in each major medium of communicative art used in conservation education activities. The Awards Committee reports, including that of the Leopold Medal, are published in this issue of the JOURNAL.

John Langenbach provided processed reports of the Committee on Employment and stated that the principal deficiency that employers found in applicants for employment or in new employees was the inability of personnel to express themselves well orally and in writing.

In presenting the report of the Committee on Job Standards, Chairman LaVerne Brugger deplored the inadequate pay received by professional wildlife employees and urged that the Society take a stand on this situation. He also recommended that consideration be given to the publication of the preceding Job Standards Committee report which suggested minimum professional standards for four types of jobs.

The completion report of the Committee on Wildlife Terminology was submitted by Chairman Louis A. Krumholz. This Committee, established in 1948 "to standardize wildlife nomenclature in accord, where possible, with standardized nomenclature recommended by related, recognized, scientific organizations," had, through successive years under five different chairmen, examined more than 600 terms, 56 of which are defined in the report published in this issue of the JOURNAL.

With the approval of the Members in attendance, reports of the Society Regions and Sections were not given at the meeting. They will be published in the WILDLIFE SOCIETY NEWS.

Under new business, Frank B. Barick of the North Carolina Wildlife Resources Commission urged that increased attention be given by the U.S. Fish and Wildlife Service and other agencies to the study of the Coturnix quail.

As no additional business was brought up, the meeting adjourned at 10:20 P.M.

Respectfully submitted,
DANIEL L. LEEDY,
Executive Secretary

ANNUAL REPORTS OF COMMITTEES

The Aldo Leopold Award

The committee to select the 1957 recipient of this medal (Fig. 1) consisted of Edward H. Graham (Chairman), Victor H. Cahalane, Arnold L. Nelson, Phil W. Schneider, and Victor E. F. Solman. The presentation was made for The Wildlife Society by President Durward L. Allen at the 22nd annual banquet of the North American Wildlife Conference. His remarks on this occasion follow:

"In 1950 The Wildlife Society caused to be struck from bronze a medal bearing the name and likeness of our great lawgiver of conservation, the late Aldo Leopold. At the discretion of the Society one of these medals may be awarded in any given year to recog-

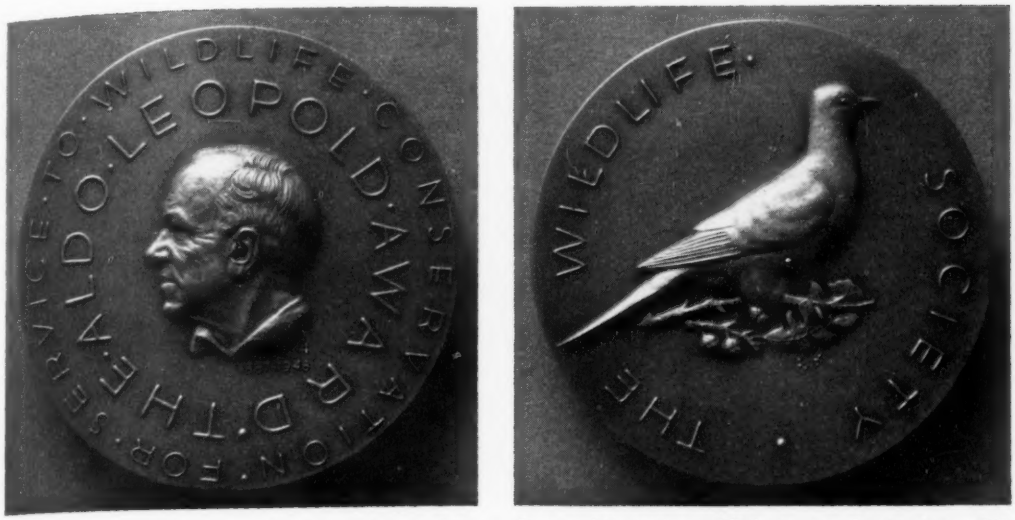

FIG. 1. THE ALDO LEOPOLD AWARD. This medal was designed for The Wildlife Society by Sculptor Gifford MacG. Proctor and struck by the Medallic Arts Co. of New York. Previous recipients were J. N. DARLING (1950), CARL D. SHOEMAKER (1951), OLAUS J. MURIE (1952), IRA N. GABRIELSON (1953), HAROLD TITUS (1954), CLARENCE COTTAM (1955) AND HOYES LLOYD (1956).

nize the highest achievement in 'service to wildlife conservation.'

"Tonight we honor a man, well known to most of you, who has devoted himself to this cause for more than 30 years. Among his virtues is a proper attitude toward utilization, for he's a fisherman and big-game hunter. Through the years he has served conservation in local clubs, in state agencies, and in a national position of great significance. In the Leopold tradition, he sees wildlife as a recreational resource, irreplaceable in our living standard, and essential to the well-being of present and future citizens. He conceives its management as part of an enlightened program for the land and all it bears.

"In each cause this distinguished American has backed we perceive a demanding principle that the interest of the whole people shall prevail—but when it doesn't, then the way of the transgressor must be made as rough as possible! In administrative offices, in legislative chambers, perhaps in even more hallowed precincts, this man has done battle. I can tell you that he has been floored a few times. But like Antaeus of old, he seems to gain strength from each contact with the earth he defends.

"I wonder how many of you know that this 22nd North American Wildlife Conference is the 11th in a consecutive series that has been arranged and held largely through the never-say-die efforts of one man? The first was in 1946, after he came to Washington from his home state of Indiana to become Vice-President of The Wildlife Management Institute.

"Actually, this annual conference is one of his minor chores. Through the monthly news bulletin and in uncounted public appearances, he has been an unfailing public-relations officer for conservation. He has been active in the supervision of the Institute's two waterfowl research stations. He has worked diligently to support and strengthen the program of the nation's 16 Cooperative Wildlife Research Units. Through the years, a succession of useful books and bulletins on North American wildlife have been published in part through his urging and his finding of ways to do things.

"I'm not going to mention the many positions of responsibility in national organizations that the recipient of this medal has held. Probably we can sum it up by saying that his record is one that few people could find the will, the courage, and the strength to emulate.

"Will Mr. C. R. Gutermuth please come to the rostrum?

C. R. GUTERMUTH, recipient of the Aldo Leopold Award in 1957

"Pink, a lot of us always knew your name would be on one of these medals. But it never occurred to me that I would have the privilege of presenting it to you. If this 22nd conference lingers with a special meaning in your memory, I can tell you that it will in mine too. This beautiful medal comes to you with our warm friendship, our gratitude, and our congratulations."

Conservation Education Awards

The Committee, having reviewed the several nominations by Society members and others, recommends two works for the 1956 Conservation Education Award.

Michael Hudoba's *Report from Washington*, a monthly presentation in *Sports Afield* magazine, was selected to receive one of the awards because of the great service done the American people by faithfully and objectively reporting conservation affairs occurring at the national level. *Sports Afield* deserves much credit for making its pages available for carrying Mr. Hudoba's forthright account of conservation affairs.

The New York Sportsmen's Conservation Workshop, Cornell University, is recommended to receive the second award. While many people have contributed to make this leadership-training program a success, it was Harlan Brumsted's organizational ability and effort that provided the impetus to put the program across. The Sportsmen's Conservation Workshop, as conceived and executed, establishes a pattern that can be adapted to any area where organized sportsmen desire to become better informed on conservation problems that are of interest to them.

There were many excellent nominations made to receive the coveted Conservation Education Award. All of these were of high quality and we believe symbolize the quality of thought and effort taking place in the field of conservation education in America.

Respectfully submitted,

ANTOON DE VOS,
HOWARD MICHAUD,
JOE PENGELLY,
CHARLES YOCOM,
FARLEY F. TUBBS,
Chairman

Fisheries Publication Award

By unanimous vote of the Committee, the award for 1955–56 goes to Louis A. Krumholz for his study, *Observations on the fish populations of a lake contaminated by radioactive wastes* (Amer. Mus. Nat. Hist. Bull., 110(4):281–367, June 1956).

Thirteen other papers were considered by the Committee, many of which were of high importance for their contributions to the science of fisheries management. For this reason, the Committee was unable to reduce the number deserving of honorable mention to less than ten. As the significance of honorable mention varies inversely with the number of papers listed, the Committee has refrained from naming the ten.

Respectfully submitted,

MERLE A. GEE,
PETER I. TACK,
GUSTAV PREVOST,
GEORGE W. BENNETT,
Chairman

Terrestrial Publication Award

The Committee had a particularly difficult assignment this year because of the large number of excellent publications that appeared during the past two years. We have been guided in our choice by the terms of reference proposed by the Committee on Awards Procedure in considering a great variety of wildlife literature issued during 1955 and 1956.

Several important monographs on North American game species have recently been published. These are mostly compilations of previously published research, and we have reserved the award for original research reports. The Committee would have liked to select one or two journal articles for nomination. Certainly many excellent articles appeared. The breadth of the field, however, made it impossible to narrow our choice to one or two. We were forced in the end to admit that several of the books were of more general importance.

We have chosen for Honorable Mention Frank C. and John J. Craighead, 1956. *Hawks, owls and wildlife.* The Stackpole Company, Harrisburg, Pa., and The Wildlife Management Institute, Washington, xix + 443pp. The Craigheads have amassed an impressive amount of data on raptor populations, territory, hunting techniques, migration, and seasonal feeding patterns. Their book is an important contribution to our understanding of predation.

The Committee also cites for Honorable Mention Robert P. Allen, 1956. *The Flamingos: their life history and survival, with special reference to the American or West Indian flamingo* (PHOENICOPTERUS RUBER). National Audubon Society, New York, Research Report No. 5, xv + 285pp. This report involves a thorough review of the world literature on flamingos as a basis for understanding local field problems.

In selecting the outstanding publication on terrestrial research, the Committee has set a precedent this year in nominating a single author for his second award. We have chosen H. A. Hochbaum, 1956. *Travels and traditions of waterfowl.* University of Minnesota Press, xii + 301pp. This book deals with the subject of bird migration, which is important both from a theoretical and practical point of view. Hochbaum has achieved a fine blend of theoretical discussion and personal research in his work.

The Committee also wishes to commend The Wildlife Management Institute for its important contributions to the wildlife field in the sponsorship of its monographic series on North American game species.

Respectfully submitted,
A. E. BORELL,
JOHN L. BUCKLEY,
CHAS. O. HANDLEY, SR.,
ALLEN W. STOKES,
A. W. F. BANFIELD,
Chairman

Employment

The Employment Committee reviewed the material gathered and published by preceding Committees. From this review it seemed evident that the Committee title was a misnomer. There were no indications that the Employment Committee had done much to assist members in securing employment, and probably less in assisting potential employers to locate available personnel.

However, previous reports had gone into considerable detail to give the educational institutions' statistics on enrollment. For the sake of continuity the current report was compiled on a similar basis. Nevertheless, there is some doubt as to its value, except as a general trend, because of lack of comparable data on a continental basis from one year to the next. Either educational institutions or individual potential employers failed to respond to the questionnaire with the resulting lack of continuity from year to year.

This Committee has initiated several features which are recommended to be continued:

1. An attempt was made to obtain personal data on the membership, even though presently employed, in order to aid willing employers in contacting potential employees who have specialized training, experience, or aptitudes to fill particular niches in the respective organizations. To date, the response of the membership has not been very encouraging, even though notices have been published in the WILDLIFE SOCIETY NEWS and other outlets.

2. In the past only state, provincial, and federal government agencies had been circularized relative to anticipated needs for trained personnel in the field of conserva-

TABLE 1.—EMPLOYMENT REQUIREMENTS OF GRADUATING STUDENTS

	B.S.		M.S.		Ph.D.		Totals	
	1956	1957	1956	1957	1956	1957	1956	1957
Game	37	58	30	85	3	16	70	159
Fish	33	49	14	40	11	56	58	145
Enforcement	2	4	—	—	—	—	2	4
Public relations	3	5	5	15	1	5	9	25
Teaching	11	18	6	18	19	99	36	135
Back to school	79	120	30	85	—	—	109	205
Military	54	84	4	12	1	5	59	101
Other	70	107	13	38	—	—	83	145
Totals	289	445	102	293	35	181	426	919

tion. This year nongovernmental agencies were polled relative to their present staff and future needs. The response was gratifying, considering the Committee's lack of knowledge relative to potential organizations and industries employing biologically trained personnel.

The Committee files are lacking the name and address of such organizations, and we would appreciate being advised by the membership of any industry, lumber company, watershed organization, philanthropic group, etc., which is employing or may employ personnel trained in conservation work.

3. The Committee has prepared and released two tables for the benefit of potential employers and employees. Each educational institution that replied to the questionnaire was forwarded a table indicating the number of new personnel each agency anticipated employing in the immediate future. Each employing agency was forwarded a table of the institutions and the number of M.S., B.S., and Ph.D. students enrolled during the present school year. These tables should enable the employers and the employees to make preliminary contacts, and probably consummate employment arrangements prior to graduation.

Table 1 is a projection of the current employment requirements based on the report of 1956 graduates by degrees received. The known percentage of job holders was calculated and applied to the reported current number of enrolled students eligible for degrees in 1957. The "other" categories include graduates who were employed in a field not specifically listed or on whom the school was unable to report. However, it must be pointed out that the response from employers was not very complete, as is evidenced below.

Table 2 portrays the indicated needs during 1957 as reported by 34 state fish and game departments, two provincial fish and game departments, two Canadian federal agencies, three U.S. federal agencies, Alaska, Puerto Rico, and ten private organizations. It is regrettable that the major U.S. federal agency employing fish and game technicians did not reply to the Committee's questionnaire. Possibly the turmoil of reorganization was responsible, at least in part. Verbal contacts with U.S. Fish and Wildlife

TABLE 2.—EMPLOYMENT NEEDS OF 51 CONSERVATION ORGANIZATIONS IN 1957

	States		Canadian Provinces		United States Federal		Canadian Federal		Private		Total	
	Perm.	Temp.	Perm.	Temp.	Perm.	Temp.	Perm.	Temp.	Perm.	Temp.	Perm.	Temp.
Game	42	257	3	3	8	5	—	—	28	—	81	265
Fish	75	239	4	—	23	218	18	75	3	—	123	532
Enforcement	79	41	12	2	9	265	16	460	—	—	116	768
Public relations	13	53	—	—	1	20	—	—	7	—	21	73
Totals	209	590	19	5	41	508	34	535	38	—	341	1,638

TABLE 3.—STUDENTS WITH A MAJOR IN BIOLOGICAL CONSERVATION, 1956–57

Name of Institution	Under	Upper	M.S.	Ph.D.	Totals
Alabama Polytech. Institute	9	5	6	3	23
University of Arizona	23	11	3	—	37
University of California (Berkeley)	—	23	2	9	34
Univ. of California (Los Angeles)	—	6	4	9	19
California State Polytechnic	4	9	—	—	13
Humboldt State College (Calif.)	66	76	6	—	148
Colorado A. & M. College	119	41	12	—	172
University of Connecticut	11	7	—	—	18
University of Florida	—	5	1	—	6
University of Miami (Marine Lab.)	—	—	16	—	16
University of Georgia	18	15	4	5	42
University of Idaho	—	5	12	—	17
Southern Illinois University	—	11	—	—	11
Purdue University	—	3	—	1	4
Indiana University	—	—	1	4	5
Iowa State College	20	13	9	7	49
Kansas State College	—	11	1	—	12
University of Kansas	—	67	11	14	92
Kansas State Teachers College	—	5	1	—	6
Louisiana State University	—	—	5	—	5
University of Maine	—	3	3	—	6
University of Massachusetts	17	11	7	—	35
Michigan State University	78	49	10	5	142
University of Michigan	17	27	12	15	71
Michigan College of Mining & Tech.	58	54	—	—	112
University of Minnesota	40	18	—	4	62
Montana State College	16	9	7	—	32
University of Nebraska	2	4	—	—	6
University of New Hampshire	10	10	—	—	20
Rutgers University	6	5	3	—	14
Cornell University	34	32	8	26	100
State Univ. New York (Syracuse)	—	—	7	6	13
North Carolina State College	22	19	3	1	45
Ohio State University	—	27	5	5	37
Oklahoma A. & M. College	12	11	11	6	40
University of Oklahoma	—	—	6	9	15
Oregon State College	131	79	25	3	238
Pennsylvania State University	—	—	9	2	11
University of Rhode Island	2	10	4	—	16
South Dakota State College	51	28	2	—	81
Texas A. & M. College	11	31	2	5	49
Utah State Agricultural College	87	37	13	11	148
Virginia Polytech. Institute	34	25	4	4	67
University of Washington	56	32	20	10	118
State College of Washington	12	11	—	1	24
West Virginia University	14	10	—	—	24
University of Wisconsin*	—	—	4	1	5
Wis. State Teachers College (Stevens Pt.)	207	76	—	—	383
University of Wyoming	15	9	5	—	29
University of Alaska	24	7	4	—	35
University of British Columbia	—	4	19	15	38
Ontario Agricultural College	—	6	3	—	9
Totals	1,226	957	290	181	2,654

* Wildlife management only; not reported here: undergraduate work in the biological aspects of conservation and graduate work in fisheries.

Service personnel indicate that there may be considerable recruitment by that agency. In addition, the Committee Chairman's personal contacts with the Federal Aid programs indicate that there are positions open on the various Federal Aid projects throughout the United States and the Territories.

Questionnaires were forwarded to 85 educational institutions and replies were received from 52 where a degree will be issued for which biological conservation training was considered the major. These are listed in Table 3 in alphabetical order of the state in which the school is located. This table, as presented, does not appear to have much value in the undergraduate groups, as in many schools the number is an estimate, or underclassmen (freshmen and sophomores) are not required to register their major. It is suggested that future tabulations indicate the underclass groups as the freshmen, sophomores and juniors. Thereby the three major columns would indicate the students eligible for a B.S., M.S., or Ph.D. degree. This would aid potential employers in knowing which schools to contact relative to specific educational background for specific vacancies.

There was an increase in total enrollment of about 19 per cent and in all degree groups except the M.S. which dropped about 5 per cent. There were 426 graduates reported for 1955–56 at all levels, compared to 421 the preceding year. Of the 426 graduates, 41 per cent were known to be employed in some phase of conservation work, while almost 40 per cent either returned to school or entered military service. The remaining 19 per cent were scattered through a variety of positions or the institutions were not aware of their location.

During the fiscal year 1955–56 the agencies replying to the questionnaire indicated employment was completed for 89 game technicians, 131 fish technicians, 314 conservation officers, and 30 public relations personnel. The question, "Do you anticipate an increased opportunity in your organization for university-trained conservation officers (wardens)?" was replied to by 41 states and provinces and 34, or 83 per cent, indicated in the affirmative. However, 66 per cent stated that residence was a prerequisite for enforcement positions. The residence requirements for game and fish technicians were so varied that they are difficult to portray in this report. However, over 90 per cent indicated that nonresidents were eligible at least at the entrance grade.

An increase in personnel was indicated by 56 per cent for game technicians, 67 per cent for fish technicians, 47 per cent for conservation officers, and 56 per cent for public relations personnel. The remaining indicated that the number of employees would remain the same, with the exception of one which indicated a decrease in game technicians.

The potential employers polled were asked to express their opinions on the question, "What are the principal deficiencies which you find in applicants for employment or in new employees?" Although there was considerable variation in the replies, over 55 per cent indicated that the major fault was the inability of personnel to express themselves orally and in writing. In other words, there appears to be a basic lack of being able to use the English language. This should be a disturbing realization to educators. If the first 12 grades are not properly training students in the use of the English language, the colleges must encourage and insist on the student acquiring this ability. Other needs indicated by employers were lack of knowledge of basic law, equipment operation and maintenance, finance and budget, meeting the public, etc.

Generally, there seems to be too much emphasis on research, which probably should be reserved for postgraduate students who seem to be especially inclined to such work. The recipients of a B.S. and M.S. degree need more training in the basic fundamentals of managing lands, waters, and people.

No replies were received from the principal conservation agency in the following states and provinces: Arkansas, Georgia, Illinois, Kentucky, Maryland, Massachusetts, Oklahoma, South Dakota, Alberta, New Brunswick, Newfoundland, Ontario, Quebec, Saskatchewan.

Respectfully submitted,
JOHN T. EMLEN, JR.,
EARL O. FRYE, JR.,
ALBERT E. HYDER,
ROBERT L. JONES,
JOHN R. LANGENBACH,
Chairman

Job Standards

In planning its work program for the year, the Job Standards Committee at first considered two projects: (1) getting the 1956 Committee report ready for publication, and (2) making a study of the salary situation in the general field of fish and wildlife conservation. However, the events of 1956 affected the whole conservation picture to such an extent that it was felt that it might be more appropriate to point up some of the more important standards problems of The Wildlife Society could appraise them in the light of the changing picture of conservation.

There are several standards problems which the Committee on Job Standards feels should be called to the attention of the Society at this time. They cover a considerable amount of ground and a complete study might well get into something like a management survey, but such a survey is neither contemplated nor within the scope of this Committee's assignment. However, they should be considered, to see whether or not policies or long-range objectives of The Wildlife Society are involved.

Considering the probable impact of some of the events of the past year on the whole field of fish and wildlife conservation, the Committee thinks that The Wildlife Society could profit by reappraising its position so it can plan a course of action which will give the profession the guidance and leadership that the future will demand. For instance, the economic surveys of the past year give considerable insight into the economic and social values of hunting and fishing, both on a state and national level. We find that we have a big business on our hands and that we are dealing in social values that affect a large segment of our population. This changes our whole perspective. The Fish and Wildlife Act passed last year gives the U.S. Fish and Wildlife Service, a traditional leader of the profession, increased stature. In the United States, conservation was a major issue in the last election. These events are harbingers of the future and indicate that the profession that we represent must meet new demands in the future.

There are some standards problems that have been with us for some time which never seem to have received the proper attention of The Wildlife Society. One is the old question of politics vs. career service, which appeared in high places again this year. This is a matter on which the Society could well afford to take a stand as far as professional work is concerned.

Another pressing problem is the question of adequate salaries for professional work. We find that a deplorable condition exists where professionally trained men sometimes receive only a little more pay than that earned by carpenters, machinists, electricians, or brick masons. This is discussed in more detail in the special report of our Committee elsewhere in this issue of the JOURNAL. The Society should take a stand on the matter of adequate pay for professional services.

A third problem is one concerning the general training and utilization of man power in the whole field of conservation. There is a general feeling on the part of management that fish and wildlife schools may stress research to the detriment of training in some of the administrative and managerial tools especially where the student is interested in management. On the other hand management often overlooks the fact that applied and operational research are valuable and effective tools of management. With the possible exception of forestry, it might be said that the whole field of conservation has been laggard in seeing that professional men operate at a level fully commensurate with their ability. While no specific recommendations are made at this time on this whole question, it is a problem that we should handle in our own ranks and one that needs attention.

Coupled to these problems is still another factor. We feel that many times the professional fish and wildlife conservationist does not receive adequate recognition for his services either on a lay or a professional level. This is a matter that should be called to the attention of the Society.

We also find that other Job Standards Committees have done a considerable amount of spade work on "type" standards. This material needs to be reviewed, brought up to date, and published.

The Committee makes the following specific recommendations to The Wildlife Society:

1. That the Society re-evaluate its present posi-

tion and determine what steps are necessary to provide continuing professional guidance and leadership to the field of fish and wildlife conservation, and that the Society take positive action to see that it continues to give professional guidance and leadership commensurate with its role as a professional organization.

2. That the Society take steps to define the specialized professional fields of fish and wildlife conservation and the general requirements of these fields.

3. That the Society take a firm stand against the practice of filling professional career positions by political appointment.

4. That the Society take a positive stand on the matter of seeing that professionally trained men receive adequate compensation for their work.

5. That the Society investigate and see what can be done about the question of professional fish and wildlife conservationists receiving adequate recognition for their efforts.

6. That the Society review and publish the minimum standards developed by other Job Standard Committees.

Respectfully submitted,
THOMAS S. BASKETT,
FLOYD B. CHAPMAN,
ROBERT F. COONEY,
W. D. KLIMSTRA,
LAVERNE BRUGGER,
Chairman

Wildlife Terminology

The Committee on Wildlife Terminology was established by The Wildlife Society in 1948 in order "to standardize wildlife nomenclature in accord, where possible, with standardized nomenclature recommended by related, recognized, scientific organizations."

Since its inception, the Committee has been guided by five different chairmen, and 22 individuals have actually served on it at one time or another. Each of those men has contributed in some way to this report.

Over the years, through correspondence and personal conference, and with the guidance and counsel of many officers and members of the Society, your Committee has decided that certain limitations should be placed on the size and scope of the proposed *Glossary of Wildlife Terms*. Only those terms that are inadequately defined in the dictionary, or are controversial, or frequently are used erroneously are included. More than 600 terms have been brought to our attention during the past nine years. Each of those terms has been examined carefully, and it is the unanimous conclusion of the Committee that the definitions of 56 terms should be clarified in a special committee report.

Our handling of this matter certainly will not meet with the approval of all members of the Society. There are, in all probability, other terms that are just as much in need of clarification, or perhaps even more so, which have not been included. Such terms were not omitted purposely. However, we ask your indulgence in this matter and submit this list for your guidance. We sincerely hope that it will be of assistance to you.

Respectfully submitted,
ROBERT W. DARROW,
OLIVER H. HEWITT,
EDWARD L. KOZICKY,
LOUIS A. KRUMHOLZ,
Chairman

BYLAWS OF THE WILDLIFE SOCIETY

ARTICLE I—NAME

Section 1. The name of this organization shall be The Wildlife Society, Incorporated.

ARTICLE II—OBJECTIVES

Section 1. The principal objectives of the Society shall be to facilitate: (1) the establishment and maintenance of the highest possible professional standards; (2) the development of all phases of wildlife management along sound biological lines; and (3) the dissemination of publications to effect these ends.

ARTICLE III—MEMBERSHIP

Section 1. The membership of this Society shall consist of the following classes: Members, Life Members, and Honorary Members.

Section 2. Membership shall be open to all persons interested in wildlife management, who have the endorsement of one or more Members.

Section 3. A person shall become a Member upon receipt of an acknowledgment from the Executive Secretary that his application and dues have been accepted.

Section 4. Honorary Members shall be persons who, upon a majority vote of the Council and a majority vote of the Members present at any stated annual meeting of the Society, are thus recognized for their distinguished service or outstanding achievement in the field of wildlife management. Honorary Members shall be exempt from the payment of annual dues.

Section 5. All classes of Members shall be entitled to vote, to hold office, to represent the Society officially when so appointed by the President or the Council, and to receive all such publications of the Society as hereinafter provided.

Section 6. Membership dues shall be $6 per year, payable from January 1 in advance. Members in arrears shall forfeit their rights and privileges and shall not be entitled to vote or to receive publications during the period of their delinquency. Members shall be dropped from the membership list upon becoming one year in arrears of dues, and shall be reinstated upon payment of the dues for the current year in which the application is made.

Section 7. Any Member may become a Life Member by paying $100 in a lump sum, or not less than $25 per year over a period of not to exceed four years. Such money shall be deposited in the permanent-fund savings account. Life Members shall be exempt from the payment of annual dues.

ARTICLE IV—COUNCIL

Section 1. The Society shall be governed by a Council, composed of the President, Vice-President, outgoing President, and one elected Regional Representative from each of the Regions defined in Section 2 hereof, which shall pursue such policies and principles as shall be in accordance with the provisions of these Bylaws, and the Statutes of the District of Columbia. The Executive Secretary shall attend Council meetings as an advisor.

Section 2. Representatives to the Council shall be chosen, one from each Region, as follows: The Regional Representative from each Region shall be nominated and elected annually by a majority mail vote of the Members residing in each Region who return ballots. Nomination ballots shall be mailed to all Members by the Executive Secretary by August 1 of each year. Each Member may nominate three qualified persons residing in his Region as his first, second, and third choice for representative from that Region. Thirty days will be allowed for Members to return their ballots. At the close of the 30-day time interval, the Executive Secretary shall tabulate the results. The Members' first choice will receive 3 points; second choice, 2 points; and third choice, 1 point. The names of the two nominees receiving the most points within each Region shall be listed on the annual election ballot. The name of any nominee for Regional Representative who also may have been nominated as an officer shall be placed on the election ballot for the officer position only, and the name of the nominee for Regional Representative holding the next largest number of points shall be placed on the election ballot for Regional Representative. In the event of a tie, the selection shall be made by a majority vote of the Council. The Audit Committee, appointed by the President, shall audit all ballots. Regional Representatives shall be eligible for re-election, and shall take office at the close of the annual meeting following their election. The Regions shall be as follows:

Region 1: Maine, New Hampshire, Vermont, Massachusetts, Rhode Island, Connecticut, New York, Pennsylvania, New Jersey, Delaware, and West Virginia.

Region 2: Virginia, Maryland, District of Columbia, Kentucky, Tennessee, North Carolina, South Carolina, Georgia, Florida, Alabama, Mississippi, Louisiana, Arkansas, Puerto Rico, and Virgin Islands.

Region 3: Ohio, Michigan, Wisconsin, Minnesota, Iowa, Missouri, Illinois, and Indiana.

Region 4: North Dakota, South Dakota, Montana, Wyoming, Nebraska, Colorado, and Kansas.

Region 5: Arizona, New Mexico, Texas, Oklahoma, and Mexico.

Region 6: Washington, Oregon, California, Idaho, Nevada, Utah, Alaska, and Hawaii.

Region 7: Canada.

Section 3. The Council shall, by a majority vote, have the power to fill vacancies

occurring in its membership; shall recommend Bylaws to the Society for action not inconsistent with the Certificate of Incorporation and the statutes of the District of Columbia; and shall perform such other duties as are prescribed herein. Five Members of the Council shall constitute a quorum for the transaction of business.

Section 4. The regular annual meeting of the Council shall be held preceding the Society's annual meeting or at such time and place as the President shall designate. Special meetings of the Council may be called by the President when, in his opinion, the business of the Council so requires, and meetings shall be called upon written request of three Members of the Council addressed to the President. Notice of all meetings shall be given to all Members of the Council, at least ten days prior to said meetings.

Section 5. In the event a Member of the Council is unable to attend a meeting, he is authorized to appoint any qualified Member of the Society as an alternate, provided that he has so notified the President in writing. The appointment of any alternate to act for a Member of the Council shall be recorded in the minutes of the meeting.

ARTICLE V—BOARD OF TRUSTEES

Section 1. A Board of Trustees, consisting of three Members, shall be appointed by the Council to administer the permanent fund of the Society. One Trustee shall be appointed at each annual meeting for a term of three years. The Trustee with the longest service on the Board shall be the Chairman. In case of vacancies caused by resignation, death, or incapacitation, successors shall be appointed by the Council for the remainder of the unexpired term.

ARTICLE VI—PUBLICATIONS

Section 1. The Society shall publish a scientific periodical to be called THE JOURNAL OF WILDLIFE MANAGEMENT, and a newsletter to be called THE WILDLIFE SOCIETY NEWS, for distribution to the membership. The JOURNAL may be sold by subscription, or by single volumes or issues, at rates prescribed by the Council. Delinquent Members shall pay the prescribed prices for back numbers. Distribution of the NEWS shall be restricted to Members only.

Section 2. The Editor and Associate Editors of the JOURNAL, and the Editor of the NEWS, shall be appointed by the Council. The Editors shall serve a term of one year, or until their successors are appointed, and shall be responsible for all matters relating to the publications of the Society, subject to such restrictions as may be imposed by the Council. The Editor of the JOURNAL shall attend Council meetings as an advisor.

ARTICLE VII—OFFICERS

Section 1. The officers of the Society shall be a President, a Vice-President, and an Executive Secretary.

Section 2. The President and Vice-President shall be elected by mail ballot, except as provided below, and shall serve until the close of the annual meeting of the calendar year following their election, and shall be eligible for re-election for two additional terms of one year each. The Executive Secretary shall be selected by a majority vote of the Council, and shall serve for an indefinite number of years, at the discretion of the Council. Before June 1 of each year, the President shall appoint a Nominating Committee of five Members, and an Audit Committee of three Members, and before September 1 of that year, said Nominating Committee shall submit to the Executive Secretary the names of two available Members as nominees for each office to be vacated. The Committee's nominations shall be published in the next October issue of the JOURNAL or the November issue of the NEWS. Within 30 days of the date of mailing of said issue, the names of additional available nominees for any office to be vacated may be submitted by any voting Member in good standing, and any such nomination shall be valid if supported by 5 per cent of the membership. The Executive Secretary shall then mail to all Members an election ballot bearing the Committee's nominations and those made by the membership as herein provided. Thirty days will be allowed for the election ballots to be returned to the Executive Secretary. The nominee receiving the largest vote for each office shall be declared elected. In the event of a tie, the selection shall be made by a majority vote of the Council. The three-member Audit Committee shall audit all nomination and election ballots. The auditors' report on

balloting shall be published in the JOURNAL or in the NEWS.

Section 3. A petition, signed by 5 per cent or more of the Members in good standing, will be sufficient to require the Council to submit a ballot to the Members to determine their approval or disapproval of the incumbent Executive Secretary. The Council may pay the Executive Secretary a salary and expenses, at its discretion, within the sound financial limits of the Society.

Section 4. The President shall preside at all meetings of the Society, shall be Chairman of the Council, shall appoint all Committees, including those established by the Council, and perform all other duties incident to this office.

Section 5. In the absence of the President, or upon his inability to act, the duties shall be assumed by the Vice-President. In the event neither can serve, the Council shall appoint a President *pro tempore.*

Section 6. The Executive Secretary shall be the Executive Officer of the Society under the general direction of the Council. He shall issue notices of annual or special meetings, and present a report of his activities during the year to the Society at its annual meeting. The Executive Secretary shall, subject to such regulations as may be promulgated by the Council, be responsible for all funds of the Society, except the management of the permanent fund, which shall be under the supervision of the Board of Trustees. The general-fund checking and savings accounts shall be made subject to the signature of the Executive Secretary, who shall have the authority and discretion to make transfers between these two accounts, depending upon the working capital needed in the checking account for current operating expenses. The Executive Secretary shall be responsible for the safekeeping of the permanent funds, including the investment securities, which shall be held in custody for the Board of Trustees. The permanent-fund savings account shall be made subject to the signature of the Executive Secretary, but no withdrawals shall be made from this account except by a majority vote of the Board of Trustees. The Executive Secretary shall be bonded at the Society's expense in the amount specified by the Council. An independent audit shall be made of his accounts at the close of each fiscal year, as directed by the President, prior to reporting at the annual meeting.

Section 7. Vacancies among the offices shall be filled from the membership by a majority vote of the Council, for the unexpired term of the office, or until the next regular election.

ARTICLE VIII—MEETINGS OF THE SOCIETY

Section 1. Unless the Council directs otherwise, the annual meeting of the Society shall be held in March of each year. Other meetings may be held at such time and place as designated by the Council. Due notice of such meetings shall be given to all Members at least 30 days in advance, either through the NEWS, the JOURNAL, or by letter or card to their last-known mail address.

Section 2. The order of business at the annual meeting of the Society, unless changed by a majority vote of the Members present, shall be as follows:

1. Approval of minutes of last meeting.
2. Reports of officers.
3. Actions on recommendations of the Council.
4. Reports of Committees.
5. Reports of Regional Representatives.
6. Appointment of Temporary Committees.
7. Unfinished Business.
8. New Business.
9. Adjournment.

Section 3. Resolutions proposed for consideration at any meeting of the Society must have prior approval of a majority of the Council, and if approved subsequently by a majority of the Members attending the Society meeting, such resolutions shall represent the official view or recommendations of the Society.

ARTICLE IX—SECTIONS

Section 1. Upon petition of ten or more Members, the Council may authorize the formation of a Section in any designated areas within the boundaries of regions but transgressing regional boundaries where convenience so requires.

Section 2. Sections shall adopt Bylaws which will become effective upon approval of a majority vote of the Council. Such Bylaws shall include provision for an annual report and financial statement to be submitted to the Executive Secretary of the Society.

Section 3. Members of Sections must also be Members of the Society. Nonmember affiliates may be provided for but shall be without power to vote or hold office.

Section 4. Sectional activities shall be related primarily to the area represented.

Section 5. Resolutions adopted by section membership must be approved by the Council before the name of the Wildlife Society may be used.

Section 6. The Executive Secretary of the Wildlife Society shall be provided within ten days with copies of all records of elections and other official action taken by Sections.

Section 7. All Sections in active status on the date of the adoption of this Bylaw shall apply for and receive official recognition from the Council.

ARTICLE X—ADMINISTRATION OF ASSETS

Section 1. The Council may accept in the name of the Corporation, any bequests, grants, and trusts made for the purpose of advancing the aims and objectives of the Society, and when so accepted, the Board of Trustees shall have the power to receive and administer said securities, funds or other property, real and personal, which may be transferred to the Society by any person, firm, or corporation; and may sell, transfer and assign, invest and reinvest the same or any part thereof, as well as any assets or holdings acquired through subsequent exchange or conversion, provided, however, that the exercise of such rights is not in contravention of the terms under which the property was accepted from the donor or devisor. Any and all monies or other assets received by the Society for special or undesignated purposes, exclusive of routine operational income, shall be held in custody in the permanent fund by the Executive Secretary, subject to the control of the Board of Trustees.

Section 2. The permanent fund of the Society shall be controlled by the Board of Trustees with full power to authorize the Executive Secretary by a majority vote, to purchase securities, sell, transfer and assign any of the stocks, bonds, or other registered securities standing in the name of the Society, and to execute, under seal, such form of transfer or assignment as may be necessary to constitute a regular transfer of said securities; and to execute and deliver in behalf of the corporation, proxies on any and all stock owned by the Society, appointing such person or persons as deemed advisable to represent said stock.

Section 3. The Council shall review the financial status of the Society, from time to time, and determine by a majority vote what funds, if any, are to be transferred from the general-fund checking or savings account into the permanent-fund savings account under the control of the Board of Trustees. When any or all of the holdings in the permanent fund are required for Society business, and when so instructed by a majority vote of the Council, the Board of Trustees shall order the Executive Secretary to effect any necessary liquidation of assets and/or transfer the stipulated amount to the general-fund checking account for use as directed by the Council.

ARTICLE XI—FISCAL YEAR

Section 1. The fiscal year of the Society shall end at the close of the last day of February.

ARTICLE XII—AMENDMENTS TO BYLAWS

Section 1. Amendments to these Bylaws may be ordered to be submitted to the membership for action either by a majority vote of the Members present at any annual meeting of the Society, or by a majority vote of the Council.

Section 2. These Bylaws may be altered or amended by a majority vote of the Members present at any regular or special meeting of the Society, if advance notice of the proposed changes is contained in the notice of the meeting, provided, however, that any Member unable to attend a meeting may request the Executive Secretary in writing before such meeting to register a vote for him either for or against the amendment in question and such votes shall be counted with the votes of the Members present. These Bylaws may also be altered or amended by a majority of the Members who return ballots in response to a proposed amendment, notice of which must have been mailed to all Members at least 30 days prior to the close of the ballot. The results of all such ballots shall be filed with the permanent records.

SPECIAL COMMITTEE REPORTS

GLOSSARY OF WILDLIFE TERMS[1]

AGE GROUP.—Organisms of the same age in a population. The age group is usually denoted in roman numerals, e.g., Age Group I, Age Group II, Age Group III, etc.

This grouping of organisms according to age is not to be confused with the grouping known as the *year class*. *See* Year class.

ANNULUS (pl. ANNULI).—A ring, arrangement of rings, or other markings formed once a year and used in the determination of age and growth in some animals, notably fishes.

On a fish scale, the annulus is usually evident as an area of disturbance in the more or less regular spacing between the circuli. The structure of the annulus is usually different for each kind of fish scale (ctenoid, cycloid, etc.).

On a fish bone or spine, the annulus is usually apparent in a specimen stained with Alizarin Red S, or some other suitable stain, as a darkly stained (more compact) area separated by less darkly stained (less compact) areas.

Annuli, useful in age determination, also are found in the teeth of some mammals.

ANTLER BEAM DIAMETER.—The diameter of the main beam of antler measured at one inch above the burr. If the beam is irregular in circumference, the diameter is derived from the average of several measurements.

BIOMASS.—The original concept of biomass was the weight of a species population per unit of area. This is now called the species biomass.

The total biomass of a community is the community biomass and is composed of the sum of all the species biomasses that compose the meshes of the food web, and whose populations make up the pyramid of numbers. (*Principles of Animal Ecology*, by Allee, Emerson, Park, Park, and Schmidt. Philadelphia: Saunders, 1949. Page 526.)

BROWSE LINE.—In a stand of woody vegetation, the line below which the foliage and small twigs have largely been eliminated by feeding animals, especially ungulates. The distance from the ground to the browse line is an indication of the maximum reach of the species in question.

The term "Plimsoll Line" should never be used in this respect because it refers specifically to the limit of submergence allowed by law for British merchant vessels.

BUFFER SPECIES.—Any nongame species that serves as food for predators and thus relieves predation on game species.

CARRYING CAPACITY.—The maximum number (or weight) of organisms of a given species and quality which can survive in a given ecosystem through the least favorable environmental conditions that occur within a stated interval of time. Here, the number of animals is an expression of the interaction of the properties of the species concerned and the total environment in which it lives. Generally, in fish and game biology, the most appropriate time interval is one year.

The term *carrying capacity* has been used in many ways by game and fish biologists during the past several decades. The above definition is, in essence, that of Edwards and Fowle (Trans. N. Amer. Wildl. Conf., 20:597). Generally, the term should be limited to a more or less theoretical concept because it is almost impossible to determine; it is difficult to ascertain at which particular time the least favorable conditions might prevail in the environment, and all too frequently such unfavorable environmental conditions make accurate field work impracticable.

CIRCULUS (pl. CIRCULI).—Each of the individual concentric circular rings or ridges on a fish scale. The formation of the annulus is usually a result of a disturbance in the regular formation of the circuli.

COMMUNITY.—A naturally occurring assemblage of plants and animals that live in the same environment and that are mutually sustaining and interdependent. This term is not to be confused with *population*, which is usually confined to a single species or class of animals. *See* Population.

CONDITION FACTOR (COEFFICIENT OF CONDITION, PONDERAL INDEX).—A numerical index, usually applied only to fishes, which represents the relationship between the length of the animal and its weight as indicated by the equation:

$$\text{Condition factor} = \frac{aW}{L^3}$$ where

a is some power of 10 required to bring the value to a standard magnitude,

W is the weight of the fish, and

L is the length of the fish. Whichever length, standard, fork, or total is used should be specified.

When metric measurements are used for both length and weight, the condition factor is usually referred to as k.

When the measurements are in inches and pounds, the condition factor is usually referred to as C or $C.F.$

[1] Prepared for The Wildlife Society by the Committee on Wildlife Terminology: Robert W. Darrow, Oliver H. Hewitt, Edward L. Kozicky, and Louis A. Krumholz, Chairman.

When the lengths are in inches and the weights are in grams, the condition factor is usually referred to as *R*.

ENVIRONMENTAL RESISTANCE.—The combined effects of all the factors of the environment that tend to reduce the numbers of animals present and thereby inhibit the full realization of the reproductive potential.

FLUCTUATION.—Relatively asymmetrical departures from equilibrium.

HARVEST.—The harvest is the number of individuals taken from a population for sport and/or commercial purposes during a certain period of time. For all practical purposes, the yield and the harvest are synonymous.

KELKER INDEX.—The principle of using the kill, from either the total population or from one of its components, in combination with a change in the ratio or proportion of any two recognizable components of the aggregate population being studied, in order to compute the numbers of either component or the total for the time just previous to the hunt or immediately after the hunt.

KING CENSUS.—A method of sampling ruffed grouse populations, adaptable to work with other species. Transect lines in a grid pattern are covered on foot. For each grouse flushed, the distance between the observer and the point of flush (flushing distance) is measured. The area of effective census is, therefore, the total length of the transect line multiplied by twice the average flushing distance.

LENGTH MEASUREMENTS (FISH)

Standard Length.—Length of the fish from the tip of the snout to the caudal end of the vertebral column (hypural plate). The posterior point of measurement is usually taken as the point of flexure at the base of the caudal fin..

Fork Length.—Length of the fish from the tip of the snout to the deepest part of the notch in the caudal fin. Can be properly used on only those fishes that possess forked caudal fins.

Total Length.—The over-all length of the fish. Usually measured from the tip of the snout or lower jaw, whichever is the most anterior, to the tip of the caudal fin with the lobes compressed to give the maximum length.

LENGTH MEASUREMENTS (MAMMALS)

Total Length.—The over-all length of the animal, measured from the tip of the snout to the tip of the last caudal vertebra with the body and tail stretched out to their maximum natural length. This measurement should not include measurements of hair.

Hind-foot Length.—Length of the hind foot from the tip of the heel to the tip of the hoof (Ungulates) or from the tip of the heel to the tip of the longest claw or nail (Unguiculates), the foot being extended to its greatest natural length.

Tail Length.—Length of the tail, measured with the tail extended to its greatest natural length at right angles to the back, from the base of the tail on its dorsal side to the tip of the last vertebra. This measurement should not include measurements of hair.

LINCOLN INDEX.—An index of the size of an animal population. This index was first described by F. C. Lincoln in 1930. A number of individuals of a population are trapped, marked, and released. Later, the population may be sampled by trapping, hunter harvest, etc., and the estimate of the total population (T) obtained from the equation:

$$T = \frac{mn}{x}$$ where

m is the number of animals originally marked,
n is the total animals captured in the sample, and
x is the number of marked animals in the sample.

This method of estimating the size of waterfowl populations is identical with that devised in 1896 by Petersen for fishes.

OSCILLATION.—Relatively symmetrical departures from equilibrium.

OVERCROWDED.—An excessive density of population in relation to carrying capacity. Under such conditions, the animals usually tend to become stunted, grow slowly, and are in generally poor condition. Overcrowding may result from natural causes, such as an improper balance between the predatory animals and their prey. In such instances, the prey species usually becomes overcrowded because of decreased or ineffective predation or from inadequate harvesting. Overcrowding may also result from improper stocking. *See* Overstocked.

OVERSTOCKED.—The stocking of an excessive number of animals in relation to the carrying capacity of the area or region and to the reproductive potential of the animal stocked. An overstocked area is not necessarily overcrowded at the time of stocking but may become so later on. *See* Overcrowded.

PETERSEN INDEX.—An index of the size of a fish population. The method was devised by C. G. J. Petersen in 1896. The salient features of the method are (a) the release of a number of marked fish into a body of water, (b) the recording of the numbers of fish caught during the period in question, and (c) noting the numbers of marked fish among the total catch. The size of the population, P, is estimated from the equation:

$$P = \frac{MC}{R}$$ where

M is the number of marked fish in the body of water,
C is the total number of fish caught, and
R is the number of marked fish recaptured.

Many modifications of this formula have appeared in the literature since 1938, but all of them are based on the same general principles.

POPULATION.—The organisms of the same species, collectively, that inhabit a particular area or region, e.g., the bluegill population of a pond, the pheasant population of a county.

Although the term *population* is usually confined to animals of a particular species, it is sometimes used to denote an assemblage of organisms that belong to an entire class of animals, e.g., the fish population of a pond, the small-mammal population of a farm woodlot. *See* Community.

POPULATION CYCLE.—Recurrent changes in the size of a population which are of such regularity or periodicity that future highs and lows are predictable.

A series of changes regarded as leading back to a starting point.

POPULATION DENSITY.—The number of animals of a certain species per unit area.

POPULATION DYNAMICS.—The aggregate changes that take place during the life of a population. The term *dynamics* indicates motion or change in motion. Hence, population dynamics should include all phases of reproduction, recruitment, growth, senility, mortality, seasonal fluctuations in biomass or total number of individuals, persistence of each year class and its relative dominance, and the effects that any or all of these exert on the well-being of the population.

POPULATION PRESSURE.—The combined forces exerted by the individuals of a population upon the other plants and animals in the community and upon the environment. Such forces may lead to a deterioration of the environment with resultant deleterious effects upon the population and/or to an extension of the range or to the occupation of less favorable habitat.

PRODUCTION.—The general term *production* means the total amount produced and consists of many facets, each of which may be readily distinguished from the others.

Total Production.—The number of individuals or the total amount of plant or animal substance produced during a certain period of time, regardless of whether or not it survives to the end of that time.

Rate of Production.—The speed at which plant or animal substance is produced.

Net Production.—The number of individuals or the amount of plant or animal substance that reaches maturity and is thus available for harvest.

PRODUCTIVITY.—Productivity denotes the innate ability of an environment to produce plant and animal life. The term *productivity* should not be confused with such terms as production, production rate, standing crop, carrying capacity, yield, etc., each of which is a measurement of some particular part of the over-all productivity.

Also, productivity should not be confused with fecundity or fertility, which are concerned with the ability of a plant to produce fruit or seed or of an animal to produce ova, sperm, or offspring.

PYRAMID OF NUMBERS.—The pyramid of numbers represents the food web in a quantitative sense, and its geometric configuration serves to accentuate the size groups of the different organisms in the community. Such pyramids are the natural result of two tendencies: (1) that smaller animals usually have a higher reproductive potential than larger animals, and (2) that smaller animals usually are the prey of larger animals.

The pyramid of numbers is especially applicable to predators. (*Principles of Animal Ecology*, by Allee, Emerson, Park, Park, and Schmidt. Philadelphia: Saunders, 1949. Pp.522–523.)

RECAPTURE.—Any animal that has been marked, released, and recaptured during the same population study. Used principally in fish population studies.

RECOVERY.—A marked animal that has been reported dead or injured. Recoveries may be reported by anyone from any place.

RECRUITMENT.—The entrance or addition of new animals to a population or community through reproduction, immigration, growth, and stocking.

REPEAT.—A banded bird that is recaptured by the original bander within 90 days of the last prior capture or sight identification.

REPRODUCTIVE POTENTIAL.—The maximal ability of a species, and hence a population, to produce offspring. This same ability has frequently been called the PRODUCTIVE CAPACITY or REPRODUCTIVE CAPACITY.

RETRAP, FOREIGN.—A foreign retrap is any banded bird that is trapped away from the original banding location.

RETURN.—A banded bird that is recaptured by the original bander at the same location after an interval of 90 days or more since the last previous recapture or sight identification.

ROTENONE.—The word *rotenone* is a noun and should properly be used only in that sense. It should not be used as a verb. Rotenone is a plant alkaloid and is the active ingredient in Derris powder, Cube, Barbasco, Akar Tuba, etc., and also in the currently available fish toxicants "Fish Tox," "Noxfish," "Chem-fish Special," etc.

The terminology associated with the use of rotenone in its capacity as a fish toxicant needs clarification. Here, there are several terms that are concerned with the various aspects of the use of rotenone in fishery research, and that are self-explanatory.

Treatment with Rotenone.—This broad term covers all phases of the use of rotenone in fishery research and should always be used instead of the

term *poisoning*. The latter term should be studiously avoided at all times because of the unfavorable connotation and the public apprehension caused by its usage.

Lake Reclamation.—This term is suggested for those studies in which restocking the lake is contemplated. The term LAKE REHABILITATION may be used in the same sense.

Rotenone Sampling.—This term is suggested for studies in which rotenone is used to obtain only a sample of the fish present and not to kill the entire population.

Eradication.—This term is suggested for studies in which it is desired to kill the entire fish population with no intention of restocking, e.g., in the removal of carp or other fish for the improvement of waterfowl habitat, or any study in which the primary goal is to obtain information on the size and composition of the extant fish population. If it is desired to kill all the fish in only a segment of the lake, such as an embayment, the term PARTIAL ERADICATION is suggested.

SEX RATIO.—The ratio between the number of males and the number of females in a population. This ratio may be expressed in a number of ways:

1. On a percentage basis in which the number of males and the number of females total 100, e.g., 43:57, 60:40, and where the number of males is listed first.
2. On the basis of the number of males per female, e.g., 0.9:1.0, 1.4:1.0.
3. On the basis of the number of males per 100 females, e.g., 104:100, 87:100.
4. Any modification of the above three ways.

The first three methods have one thing in common; the number of males is always listed first. Methods 2 and 3 are essentially the same; Method 2 uses decimals whereas Method 3 uses whole numbers.

There are many who prefer to list sex ratios as percentages. However, it has been the editorial policy of the JOURNAL OF WILDLIFE MANAGEMENT for many years to request authors to list sex ratios as the number of males per 100 females. There is much merit in following such a standardized procedure.

STANDING CROP.—The total number or the total weight (biomass) of animals present in an area or region at a given time. This term may be applied to a single species or to all animals in the community.

SURPLUS STOCK.—That portion of the population, present at the time of harvest, which is in excess of that required to maintain an adequate breeding stock. Under proper management, the surplus stock in that portion of the population of game animals or fish which should be harvested.

VARIATION.—A divergence in structural or physiological characteristics from the typical or usual in the group to which it belongs.

WILDLIFE.—Wild vertebrates, other than fishes. In practice, we are interested particularly in those vertebrates in which man has a management interest for either sporting or commercial purposes and which are covered by the various federal and state laws.

YEAR CLASS.—Animals in a population that were born during a particular calendar year. The year class is usually denoted in Arabic numerals, e.g., 1956 year class.

This grouping of organisms according to year of birth is not to be confused with the grouping known as the *age group*. *See* Age group.

YIELD.—This is the crop that is harvested. It is the number of individuals or the segment of the biomass that is removed from the population during a certain period of time. The yield is one of the best available indicators of that portion of the net production which is utilized. For all practical purposes, the *yield* and the *harvest* are synonymous.

SALARIES OF FISHERY BIOLOGISTS AND WILDLIFE BIOLOGISTS[1]

At the present time there seems to be some question of whether or not the salaries of fishery biologists and wildlife biologists are comparable to those of scientists and professionally employed persons in other scientific fields. Actually, there is not enough factual data available to make this determination, although several of the professional organizations seem to be making some kind of a survey of this type at the present time. The American Chemical Society has published an excellent survey (Fraser, 1956), but this is the only one available as far as we know. Therefore, it is hard to say just where the salaries of fishery biologists and wildlife biologists stand in comparison to the salaries of other sciences and professions.

The question of salaries in the field of fish and wildlife conservation is complicated by several factors, chief among which is the fact that most of the states have for all practical purposes established salary ceilings by legally pegging the top jobs. Add to this the fact that most of the jobs are with some kind of governmental organization and it is easy to see that a true comparison is hard to make, for gov-

[1] A Special Report of the Committee on Job Standards, 1956–57: Thomas S. Baskett, Floyd B. Chapman, Robert F. Cooney, W. D. Klimstra, and LaVerne Brugger, Chairman.

TABLE 1.—COMPARATIVE SALARIES

Region	State Salaries		U.S. Navy Wage Board Rates		
	Fish-restoration Projects	Wildlife-research Projects	Carpenters	Machinists and Plumbers	Brick Masons
Far West	$5,125	$4,858	$5,096	$5,241	$5,512
Southwest	4,515	4,243	4,638	4,763	4,888
North Central	4,787	4,670	4,867	4,992	5,117
Southeast	4,531	4,496	4,763	5,034	5,158
Northeast	4,299	4,333	4,867	5,013	5,133
National average	$4,604	$4,513	$4,846	$5,009	$5,162

ernmental pay systems are also defined by law. This means that one will end up comparing systems and not salaries developed under a competitive wage system.

While there are insufficient data available to come to any conclusions as to how salaries in the field of fish and wildlife biology compare with the other professional fields, there are sufficient data on which to make a comparison with some of the more common jobs in the crafts and trades. For this purpose, data assembled by the Branch of Federal Aid of the U.S. Fish and Wildlife Service on averages of state salaries paid on fish-restoration projects and wildlife-research projects under the Federal Aid program are compared with typical U.S. Navy Wage Board rates for carpenters, machinists, plumbers, and brick masons. Since the Branch of Federal Aid made determinations for the far west, southwest, north-central, southeast, and northeast regions, as well as for nation-wide employment, Wage Board rates were determined for naval installations in similar areas.

These data on the average salary for state personnel on fish-restoration projects are given in Table 1, along with comparable averages for men on wildlife-research projects. In this table, we have used current and representative Navy Wage Board data, a standard 40-hour week, and a 52-week year, to arrive at annual wage rates for carpenters, machinists, plumbers, and brick masons.

It is notable that in only one case, that of personnel on fish-restoration projects in the far west, did any of the average salaries even exceed the average annual wage rates of carpenters, either on a regional or national basis. This is a deplorable position for a profession to be in, and one that the profession can hardly defend.

LITERATURE CITED

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REVIEWS

Wildlife Law Enforcement. By William F. Sigler. Wm. C. Brown Company, Dubuque, Iowa. 1956. xxiv+342pp., illus. $4.50.

It has been said that necessity is the mother of invention. This book is a case in point. Although law enforcement has played an important part in wildlife management for decades, very little has been written on the subject. When the author began to develop a course in game-law enforcement for inclusion in his wildlife management curriculum at Utah State Agricultural College, he found that suitable text material was not available; and so with commendable energy and dispatch, he corrected the deficiency by writing a manual.

Although the title might lead one to believe the book is decidedly limited in scope, quite the opposite is true. In addition to students, game administrators, wildlife biologists, research workers, sportsmen and game protectors regardless of their experience will all find this volume enlightening, thought provoking and a valuable addition to their reference libraries.

The first chapter of the book is devoted to a historical review of wildlife management and the importance of law enforcement to the conservation program. Other chapters cover such subjects as state and Federal jurisdiction over wildlife, the rights of the citizen in respect to wildlife, types and significance of violations, qualification standards for enforcement personnel, fundamentals of law enforcement and finally a chapter on what the future holds. Interspersed throughout the text are pertinent excerpts from numerous court decisions which have had a bearing on many of the conservation policies and management practices presently in vogue.

In the chapter devoted to Federal jurisdiction over wildlife the author has done an excellent job of condensing several of the more important Fed-

eral Conservation Acts, but in one or two instances he has inadvertently created the wrong impression as to the actual wording of an act by taking certain passages out of the context. On page 27 in his explanation of the migratory-bird hunting stamp act the subject paragraph should read as follows:

"The term 'migratory waterfowl' as used in this act means wild ducks, geese, swans and brant. No person who has attained the age of 16 years shall take any migratory waterfowl unless at time of taking he carries on his person an unexpired Federal migratory-bird hunting stamp which has been validated by his signature written in ink across the face of the stamp—except that no such stamp shall be required for the taking of migratory waterfowl by Federal or State Institutions or official agencies, or for propagation, or by the *resident owner, tenant,* or *share cropper of the property* for the killing, under such restrictions as the Secretary of the Interior may by regulation prescribe, of such waterfowl *when found injuring crops or other property.* In other words, waterfowl hunters who have attained the age of 16 years are required to have a validated migratory-bird hunting stamp on their person when hunting. Farmers and others while engaged in waterfowl depredation-control activities by virtue of a waterfowl-killing permit issued by the U.S. Fish and Wildlife Service are not required to have a stamp."

On page 28 the author mentions that the Secretary of the Interior is authorized to cooperate with states and territories in the enforcement of this Act. The Migratory Bird Hunting Stamp Act is a Federal revenue measure, and in consequence the sole responsibility for its enforcement rests with the Federal government.

On page 29 the paragraph on the Bald Eagle Act should be corrected to show that in Alaska Bald Eagles may be killed only when committing damage to fishes, other wildlife, domestic birds and animals. No bald eagle so killed, or the carcass or any part thereof, including feathers may be possessed or transported for any purpose (Section 46.111—Federal regulations pertaining to Game and Fur Animals, Birds and Game Fishes in Alaska).

Some criticism might be leveled at the author for having allotted so much space to definitions, legal terms and sample examination questions. Any such criticism appears to me to be unwarranted, for Dr. Sigler's book is essentially a text for use in teaching, and the rather voluminous appendix is quite essential.

The bibliography is of particular value as it not only lists the source of much of the material in the book but also provides 150 sources of additional information. The book, dealing as it does with basic enforcement methods and procedures applicable to the conduct of game-law-enforcement activities in each of the 48 states, is deserving of, and I hope receives, a welcome reception from conservationists everywhere. This very useful and informative publication should be on the required reading list of all professional conservationists and certainly of all game-law-enforcement personnel.—CHARLES H. LAWRENCE, U.S. Fish and Wildlife Service, Washington 25, D.C.

A Report on the Whooping Crane's Northern Breeding Grounds, A Supplement to Research Report No. 3, The Whooping Crane. Edited by Robert Porter Allen. National Audubon Society, 1130 Fifth Ave., New York 28, N.Y. 1956. 60pp. $2.50.

Seldom does a report on ornithological discovery pack the drama found in this document covering the project cosponsored by the Canadian Wildlife Service, the U.S. Fish and Wildlife Service, and the National Audubon Society. It is, as stated, a supplement to Bob Allen's report, *The Whooping Crane* published in 1952, and tells the story of the nine years' search for the nesting ground (1945–53); its discovery in 1954; the exasperating efforts to reach the area by air, by water, and by land in 1955; a description of the nesting habitat; and an appraisal of the nesting in the area explored in 1955.

It is significant that the editor, drawing on his previously published fund of information, emphasizes the fact that much historical testimony indicates that the whooping crane never was an abundant bird. There is, for instance, the comments of Samuel Hearne who, during his Canadian travels of 1770–71, stated, "They are generally seen only in pairs, and that not very often." The important element in their decline has been the shrinking of their nesting area from thousands of square miles occupied in the United States alone to an area of uncertain size centered apparently in the northern sector of Wood Buffalo Park in Alberta and the Northwest Territories.

If this scattered dispersal has always been a characteristic of the species, the present scarcity on the nesting ground may be normal for the area under observation. There is also the fact that there are numerous records of whooping cranes and possible nestings at high latitudes, even as far north as the Mackenzie Delta. With the security inherent with such environments, far from the disturbing elements of civilization, this breeding area, though limited by the shortness of the season, will continue for many years to remain essentially as in the past. For the welfare of the remnant of the whooping crane population, attention must therefore be centered on the birds in migration or while they are on their wintering grounds. Fortunately both their summer and winter homes are on refuge areas —the Wood Buffalo Park in Canada and the Aransas National Wildlife Refuge in the United States. This recalls an incident that occurred in 1941 when the reviewer observed two whooping cranes that spent probably a week on or about a section of land in eastern Colorado. This square mile, with its two

small water holes, was the only one of more than 100,000 in the state that was designated at that time as a Federal refuge! Did someone say that these birds could not read refuge signs?

Nine years of search (1945–53) by air, by car, and through the media of extensive questionnaires by mail, radio, and personal inquiry resulted in a general conclusion that the nesting ground would be found at the higher latitudes, far to the north of populated areas. Many of the promising locations previously considered were eliminated, one by one, by failure to find any evidence of nesting. The course of migrating birds gave strong indication that the area lay in the direction of Lake Claire, and the shores of Lake Athabaska and Great Slave Lake. How much these efforts resembled the search for the proverbial needle in the haystack was exemplified by Allen's experience on June 25, 1947 when he was flying with Bob Smith, pilot-biologist of the Fish and Wildlife Service. On that day, after cruising along the north shore of Great Slave Lake, they swung around and scouted around Buffalo Lake, then turned east on a course that brought them back to Fort Smith. En route, as they passed over the headwaters of the Klewi and Sass rivers, a rain squall suddenly cut off visibility. There they were over the very area where nesting birds were found later! Five years later (1952) Smith saw two birds north of Great Slave Lake and in a letter to Allen stated that "you and I flew over the same area once in 1947 and again in 1948 . . . It took us twenty minutes to find the first one a second time and we knew almost exactly where he was."

It was not until July, 1954 that word reached the Audubon Society that W. A. Fuller, mammalogist of the Canadian Wildlife Service, had seen six whooping cranes, including one young, in the northern part of Wood Buffalo Park. The discovery was made on June 30 and, as Allen put it, "this proved to be the real thing." There followed in 1955 a series of exasperating experiences in an endeavor to reach the nesting area by helicopter, canoe, and on foot but a camp was finally established late in June and ten days spent in profitable observations in the area.

The breeding population of the area in 1955, based mainly on the careful records of mammalogist Fuller, was considered to be 20 adults and 8 young. It is Allen's opinion that the "birds north of Great Slave Lake are more likely to be wandering nonbreeders, and that all of the nesting pairs will be found in the pothole habitat between the Nyarling and the East Branch of the Sass."

Appendices include lists of the plants and invertebrates in and near the nesting ponds, and of birds and mammals of the nesting area with ecological notations on them mainly in June along the Little Buffalo River and lower parts of some of its tributaries.

Since the finding of the nesting ground of the whooping crane is merely a forward step in the program of learning how best this species may be kept from extermination, it seems appropriate to mention in this review a subsequent event in this process. A conference was called in Washington on October 29, 1956 by the Director of the Fish and Wildlife Service which was attended by more than 50 individuals interested in the preservation of this species. Whereas there was a diversity of views expressed between those who felt artificial propagation was the answer and those who were inclined to give Nature every possible chance to operate successfully in the wild, no formal action was taken. A permanent committee of 11 was appointed, representative of governmental and private agencies and individuals vitally concerned with the welfare of these birds.

To those who wish to inform themselves on what has been done to solve the enigma of the whooping crane's nesting ground, this attractively compiled document will answer their needs and, at the same time, provide exciting reading.—E. R. KALMBACH, Boulder, Colorado.

Manual for Analysis of Rodent Populations. Compiled by David E. Davis. Lithoprinted by Edwards Bros., Ann Arbor, Mich. 1956. iii+82pp., illus. $1.00. [sold by D. E. Davis, School of Hygiene and Public Health, Johns Hopkins University, Baltimore 5, Md.]

The value of this well-organized publication is that it describes the method used by the Division of Vertebrate Ecology of Johns Hopkins University in collecting and analyzing data on wild rodents in their native habitats. Mammalian ecologists have long needed a reference book on the technique of live-trapping, as applied to the study of populations of small mammals; and the present manual fulfills that need admirably.

Quite rightfully, the introduction points out that the procedure described is definitely arbitrary. Alternative methods are recognized; and by implication it is admitted that under certain conditions other mammalogists when studying populations may prefer different ways of obtaining information and analyzing data.

In fact, the introduction emphasizes that the booklet is "not written for the experienced mammalogist or vertebrate ecologist." It is designed instead for such persons as agriculturists, foresters, and officers of the armed forces and public health agencies who must deal occasionally with rodents that destroy crops, prevent regeneration of forests, and spread disease. These people, "in spite of lack of personal experience with mammals," may be called upon, from time to time, to collect and interpret data about numbers, reproduction, mortality, and movements of rodents. Now, through the publication of this handbook, a detailed account of an effective way of getting that information is available.

The first chapter by V. F. Flyger and D. E. Davis thoroughly covers all topics from building traps and laying out the grid to handling, marking, and sexing captured animals. Then follows a longer chapter by Flyger, F. K. Hilton, J. J. Christian, and R. Mansueti on the analysis of data through application of mathematical formulae. This latter procedure, although informative when its limitations are realized, may be dangerous in the hands of a novice. It can give a false impression of exactness and finality to conclusions which of necessity are drawn from few precise data, compared with the overwhelming number of variables and unknowns to be encountered when one studies a population of wild animals in the field. No amount of mathematical treatment can make basic data more exact than what they are. For that reason, "disciplined subjectivity," as advocated by some sociologists, along with critical discussion of data sometimes is more rewarding than a purely mathematical approach. But since it requires considerable experience with one's subject, it can hardly be recommended for the novice.

This leads to the question as to whether or not the live-trapping technique is suitable for persons who have had no "personal experience with mammals." My belief is that it is not. I think that the probability of compounding an unacceptable number of errors during the trapping, identifying, marking, examining, and releasing of animals is too great. And unless correct appraisal of data can depend on mathematical formulae, then experience with trapping and with the behavior and distribution of small mammals also is an essential background for the analytical procedure. I do not believe that the analysis of data from live-trapping should be undertaken by a "central office," as suggested in the booklet. It should be done only by the trapper, for he alone is familiar with all variables in the field.

Accordingly, it seems to me that this manual may be less useful to the forester and agriculturist than was intended, but a great deal more valuable to the professional mammalogist and ecologist than was realized. Not only the main part of the booklet but also the notes, which constitute a chapter in themselves, contain much interesting and instructive information. And in the appendices, R. Traub tells how he collects ectoparasites; R. Lord, blood samples; J. J. Christian, organs; and L. Adams gives a method for estimating seed consumption by rodents. The drawings by Fritz Hilton serve their purposes well; the front cover is especially attractive.

Altogether, this detailed account of the procedure of the famed Johns Hopkins school of rodent ecologists will be a valuable reference manual for any scientist who investigates a population of small mammals. Even if he does not follow the program set forth, he can use the booklet profitably to check the effectiveness of his own technique and to make modifications to meet new situations. The manual also will serve for laboratory exercises in mammalian ecology; the student who collects and analyzes data according to the steps that are given will learn a lot about wild rodents.—LLOYD TEVIS, JR., Division of Biology, California Institute of Technology, Pasadena, Calif.

The Desert Bighorn Sheep in Arizona. By John P. Russo. Arizona Game and Fish Department, Phoenix. 1956. 153pp., illus.

This attractive bulletin is divided into two parts. Part I reports a study of life history, ecology, and management with discussion covering most bighorn herds and habitats in Arizona. Part II deals with a collection study on the Kofa Game Range. One desert bighorn and one mule deer were collected monthly over a period of 12 months. Body measurements, stomach analyses, and findings from field and laboratory examinations of the specimens are reported.

Thoroughness of preparation for field work is impressive, and arrangements for laboratory analyses are equally complete. Assiduous care to extract maximum scientific value from each animal collected is also evident.

Included in the introduction is the remark, "This paper is a generalization and is not intended to represent a specific or complete technical study." Despite this limitation recognized by the author, the bulletin closes a number of gaps in our information and expands the earlier writings of Hornaday and Halloran on the desert bighorn.

However, the bulletin also has its shortcomings, many of which may be due to insufficient editing. The short chapter, "Association with Other Species," for example, begins with six paragraphs that do not deal with the title subject. Of 18 tables in the chapter, "Stomach Analysis," only three pertain to that topic.

Tables often are presented ineffectively. Some objectionable features are: incomplete titles, omission of units of measure, and inadequate explanation of terms. None of the tables concerning vegetation classify plants as forbs, shrubs, or trees. Only scientific names are listed. A reader unfamiliar with desert flora thus loses much of the significance of plants being discussed. In Table 11 the "availability" classes are: "Heavy locally, common locally, abundant locally, heavy, common, and abundant." These terms are not definite. Similar criticism applies to "use" classifications.

A number of statements are contradictory. One example appears on page 86. "Intensive predator control by means of poison stations and trapping, especially during the lambing season and during periods of bighorn concentration around watering holes, is recommended in a management program." Following this is the recommendation that trapped

sheep be moved to "a historic bighorn range, which has been thoroughly investigated for similar habitat requirements, lack of competition with stock or feral animals, and a normal predator population."

Past confusion in scientific classification of desert bighorn subspecies is pointed out, but little clarified. It is not until page 22 that subspecies *mexicana* is mentioned. An acceptable common name is not clearly indicated, nor is the complete scientific name *Ovis canadensis mexicana* given.

In several places a more thoughtful analysis of the data might have altered the emphasis of certain points and developed more significant conclusions. This deficiency may be related to the almost universal handicap that state wildlife technicians encounter in publishing their findings. Organizations are faced with the urgency to publish technical results promptly and to begin new investigations. This must be done with a handful of qualified men attempting to answer management's needs. Under such conditions, inadequate time for manuscript preparation is common. And consequently, many useful facts reposing in the files and minds of wildlife technicians are not now serving our profession.

Although *The Desert Bighorn Sheep in Arizona* has its weaknesses, the results presented will interest administrators, wildlife managers, and sportsmen. Important suggestions for management are given. The detailed reporting of stomach analyses, measurements, weights, and autopsy results from collected bighorn specimens is a particularly important contribution.—DWIGHT R. SMITH, Fort Collins, Colorado.

Birds and Men. By Robert Henry Welker. Harvard University Press, Cambridge, Massachusetts. 1955. 230pp., illus. $5.75.

Men have always been interested in birds. To savage man, birds were chiefly a source of food or of materials for various purposes. Yet even prehistoric peoples were inspired to depict them in drawings on cave walls, and in such primitive cultures as that of the American Indian they were used as symbols in tribal rites and as motifs for decoration. As civilization has progressed within the span of recorded history, birds have increasingly become subjects of literature and art, objects of scientific study, and finally, a matter of concern in terms of conservation.

In *Birds and Men*, Welker traces all this in informative and readable style. In his Introduction he briefly sketches the early record: from the Stone Age through the times of Aesop and the ancient Hebrew poets to the civilizations of Egypt, Greece and Rome in the pre-Christian era; and from eighth century England through medieval Europe to nineteenth-century America since then. But his primary theme deals with developments in America from 1800 to 1900.

Against a background of the discovery of North America and of a rising interest in scientific ornithology, both here and abroad, the contributions of Wilson and Audubon, and their impact on both science and art, are discussed in some detail. Both had the unique opportunity of exploring a new country with an ornithological surface that had hardly been scratched. Wilson is characterized as "pioneer and prophet," Audubon as "fulfilling genius." Audubon was essentially an artist. In the words of the author, he was ". . . not a scientist with a talent for drawing, as was Wilson; he was instead a great painter of bird life, with a talent for ornithology." A wealth of material is included regarding the circumstances associated with the work of each, and woven into both accounts is a great deal of information concerning other naturalists of early America. In assessing the high quality of Audubon's painting, Welker presents much interesting information regarding the trend in bird art prior to the appearance of the great artist-naturalist. The reviewer cannot agree, however, that Audubon ". . . became the only great bird artist yet to appear in the Western world."

Turning to literature, the attention given to nature, and birds in particular, by Thoreau, Emerson, Burroughs, Whitman and other contemporary writers is correlated with that of earlier authors and poets. Welker sees the bird essay, developed during this period, as ". . . a form of expression which burgeoned in the nineteenth century and [in the hands of Thoreau and Burroughs] made the love of birds a famous cause."

In the wake of Wilson and Audubon, and fostered by explorations into the unsettled parts of the country, came an expanding knowledge of its avifauna. A variety of Federal and state bird books were published, and the number of persons interested in birds increased greatly. Gradually, the realization began to crystallize that wildlife cannot stand unlimited exploitation. But, although many states enacted protective laws, enforcement was weak. It remained for the disappearance of the passenger pigeon and the wholesale slaughter of certain species for the women's millinery trade to provide the issue that would ultimately culminate in effective regulation. At the same time, hunting for sport was beginning to supplant hunting for food, and the concept that a legitimate harvest of surpluses could be taken—the basis of modern conservation—began to germinate.

Birds and Men is a book to be read and enjoyed. The author has chosen and organized his material well. His comments on the men he discusses and their times are objective and discerning. The typography is pleasing. The illustrations include examples of bird art of different periods and of ladies' fashions when bird plumage was in style. The reviewer found only three printing errors.—ROBERT W. DARROW, New York Conservation Department, Albany, N.Y.

A Manual of Aquatic Plants. By Norman C. Fassett with a Revision Appendix by Eugene C. Ogden. University of Wisconsin Press, Madison. 1957. 405pp., copiously illustrated with line drawings. $6.50.

Here is an old friend in a new reprinting. Dr. Fassett's 1940 classic on identification of aquatic and marsh plants is so well known that it hardly needs comment here. In the 1957 edition, the original text is retained intact but to this is added a Revision Appendix by Eugene C. Ogden. This, when used with the original text, enables the reader to determine the presently accepted scientific names of aquatic and semi-aquatic plants in the region extending from Minnesota and Missouri eastward to the Gulf of St. Lawrence and Virginia. The index is revised to include references to both the old and new sections.

Dr. Ogden, who is State Botanist of New York and an authority on the pondweeds, has done a thorough job in noting changes in names and taxonomic concepts that have occurred during the past 17 years. But as he states in his preface, "It will be readily understood that a complete revision cannot be handled in an appendix . . . ." With this we concur and feel that it is too bad that a complete revision was not made and the necessary changes incorporated in the body of the text. To be sure of a name the reader must often compare the text with the appropriate part of the Revision Appendix. This arrangement is somewhat reminiscent of trying to use the voluminous corrigenda and addenda section attached to James Joyce's *Finnegan's Wake.* However, even with its awkward arrangement, this book is the best and most definitive treatment on aquatic and marsh plants of our region and is a useful addition to the working library of any wildlifer.

It is hoped that this Manual, in which the nomenclature is brought into conformation with recent editions of the botanical bibles—Gray, and Britton and Brown—will lead to some stability in the scientific names of aquatic plants. Possibly this is too much to hope for. Too often it appears that the *correct name* is just one systematist's opinion and another can, and often does, change it—with ensuing confusion in the literature and minds of field biologists.

Consider as a horrible example, the Canada Waterweed. Everybody knows this common American plant which once ran rampant as a weed through the waterways of Europe. The old generic name was *Elodea.* Then came *Philotria* and *Anacharis* and this last name was accepted for a while (the 1940 edition of Fassett uses it). Now the cycle has come to a complete turn and it is *Elodea* again. Let us hope it stays there! The field botanist who struggled to learn the narrow-leaved pondweeds is also in for a start; for in the new edition *Potamogeton panormitanus* becomes *P. pusillus* and the *P. pusillus* he knew in the old edition becomes *P. Berchtoldii.* And, of course, their varieties do a botanical version of musical chairs.

Dr. Ogden appears to lean toward the "lumper" school of systematics and to recognize that certain aquatic plants are very variable. He includes the protean *Potamogeton gramineus* under three entities and *P. lucens* and *P. angustifolius* are lumped under *P. illinoensis.* This seems to be a happy solution, for this closely related and extremely variable complex has been a taxonomic mare's nest for more than a century and a happy hunting ground for taxonomic splitters and baptisers.

Readers will also be interested in the new treatment given the cattails and the smartweed, *Polygonum punctatum.* In the case of the latter, following Fassett's 1949 paper, two taxonomic entities become eight and one has the wonderful name of *Polygonum punctatum* var. *confertifolium* forma *longicollum.* We suggest that this be uttered only in liturgical tones and when in cap and gown.

The book is well printed, free from typographical errors, and the plates, as everyone who has used the old edition knows, are excellent.—JOHN B. MOYLE, Minnesota Department of Conservation, St. Paul 1, Minn.

The Numbers of Man and Animals. Edited by J. B. Cragg and N. W. Pirie. For The Institute of Biology by Oliver & Boyd, Edinburgh and London. 1955. vi+152pp. 15/.

This little volume is to me typically British—terse, succinct, clearly written, and therefore interesting. It presents thirteen papers by as many men contributing to a symposium held September, 1954. The discussions which followed the papers are included and are frequently fully as exciting. The authors are all British but one, Thomas Park. Each is a well-known investigator in his own special field, and in this lies the strength of the volume.

Economist, anthropologist, demographer, physiologist, mathematician and field, laboratory and human ecologists focus on the same question and present a healthy diversity of views. The gamut of opinions ranges from those who look at history and are pessimistic like Frank Darling, to those who dream of what the future could be, like Lord Boyd Orr. Some chapters are new, others are summaries, nearly all are stimulating. Skellam shows that mathematics need not be used as a statistical tool alone but can be a new creative approach for ecological thought. Lack's exposition of food as the chief regulatory force in animal populations has been more fully expounded in his recent book. Chitty avoids the appeal of the single-factor explanation and digs deeply into the physiology of long-term effects of crowding.

On the human side Banks documents the terrible impact that a single health team, immunizing or spraying DDT, can have in disrupting a primitive people. The imposed imbalance of births and deaths brings sudden changes to which our culture had

100 years to adjust. The big need for human population control was repeatedly stressed; the relative difficulty in financing research to find methods to prevent people rather than to kill them (by war) was noted. The implications for man of such developments as telegenesis (artificial insemination with frozen semen stored for years) and the possibility of extending control of infant mortality to the pre-natal period and thus getting a preponderance of males in the population, are fascinating if a bit disquieting.

For those interested in the physiological effects of population density on various animals, the chapters by Chitty, Parks, and Hammond are especially recommended. However, it is disappointing to find how little of the relevant wildlife literature from North America is known abroad. In the chapter on "The Effects of Nutrition on Fertility," the basic work by Morton and Cheatum was not mentioned. Perhaps more symposia of even broader types may help to bridge this gap between the disciplines.—WM. H. ELDER, University of Missouri, Columbia, Mo.

Tomorrow's Birthright: A Political and Economic Interpretation of Our Natural Resources. By Barrow Lyons. Funk and Wagnalls Company, New York. 1956. vi+423pp. $5.00.

In the United States, explosive population growth and unrestrained resource exploitation produced the highest living standard in the world, but not without cost. About a fourth of our tillable land is severely eroded. Five hundred thousand acres are still destroyed annually for crop production, although existing knowledge would permit a balancing of soil destruction and repair. Wind damaged 13.2 million acres in the dust bowl during 1954, but eighty per cent of this damage could have been prevented by land planning similar to that on the 4.9 million farms in soil conservation districts. Even more tragic is the continued loss of our soils with "normal" climatic conditions.

The destruction of forests to provide needed agricultural land for the colonists created a disregard for this resource which persists and extends even to those areas where vegetation is essential for watershed protection. Conflicting interests prevent the multiple use of products which would permit adequate forest management.

Lack of sufficient water presently limits expansion of population and the economy in many regions. Waste, pollution, short-term planning, interagency squabbles and monopolistic interests prevent best use of the water available. Nowhere has the characteristic American drive for immediate material wealth at the expense of future economic standards been as evident as in the monopolistic growth of the petroleum and metal industries. In the exploitation of these and other resources, the attitude of legality has dominated that of morality. The public has not accepted responsibility for the wise use of resources because of indifference, ignorance, or the chance to make a fast buck.

Mr. Lyons states in his preface that: "Natural resources are one of the most important links joining a nation's past, present and future, because they form the continuing base for the production of material goods. . . . Yet today, despite our extensive and steadily increasing technical knowledge, the progress made in attaining goals that spell national survival is relatively small." Continued progress in management of our resources depends on an enlightened, responsible public. Obviously, only the government can successfully cope with conflicting interests in protecting the public's resource rights—but the public must first demand these rights.

Tomorrow's Birthright bridges the gap from ignorance to understanding of the conflicting interest of the public, private companies, and government bureaus in the resource field. It is a blow-by-blow description of the political-economic fight over natural resource use. As such, it provides the essential background for combating the difficulties in the way of progressive legislation. In spite of all past failures, however, the author shows reason for optimism in the future.

Mr. Lyons' wide experience in journalism and in government service provides the basis for an informed discussion of the resource problem. It seemed, however, that the consequences of improper resource management were not given sufficient space. His definition of a high living standard must also be somewhat different from mine. Several paragraphs were used on an enthusiastic discussion of the culture of algae and yeasts as a source of food and other synthetic products which we will need as our population grows. I should prefer to see less growth in population and more steak. Wildlife and other esthetic values were given small consideration in the discussion of multiple-use forestry, power dams, etc. Such values are a real part of our American standard and cannot be replaced with yeast, gadgets, or engineering monstrosities.—CALVIN J. LENSINK, Department of Forestry and Conservation, Purdue University, Lafayette, Ind.

History of the Committee on Conservation of Forests and Wildlife of the Camp Fire Club of America, 1909-1956. By Charles Banks Belt. The Camp Fire Club of America, 19 Rector Street, New York 6, N. Y. 1956. ii+76pp.

This attractive and well-prepared account describes something of the thinking and activity that went into efforts to promote conservation for both New York State (pp.3-24) and for the nation (pp.24-69) during the past 47 years. Twenty-three different problems and projects are described at the state level; 43, at the national or international level. In this second category, which will interest many

readers of the *Journal*, are the efforts to set up standards for the national park system in the United States and brief histories of successful attempts to create or preserve 11 national parks, 2 national monuments, 1 national forest, and other elements of the public domain. Another broad area covers the work to save vanishing wildlife: the Pribiloff fur seals, the American bison, elk, antelope, Key deer, Dall sheep, and waterfowl. The volume closes with a bibliography of 11 titles and a 5-page index.

Through the pages of this booklet march the sturdy members of the Camp Fire Club and the men they worked with. Their names have a high place on the Honor Roll of American Conservation: William T. Hornaday, Augustus S. Houghton, Horace M. Albright, William B. Greeley, John B. Burnham, T. Gilbert Pearson, Karl T. Frederick, and others.

This history of a committee is to a certain extent, as its author rightly points out, a history of developing concepts of conservation over half a century. It is a rather modest report on a movement of tremendous significance to both New York State and the nation. One only wishes that the account was longer. There is still need for an intimate history of American conservation along the lines of Gifford Pinchot's unforgettable autobiography, *Breaking New Ground*. Mr. Belt's account is properly factual and only hints at the wealth of drama behind the conservation movement. The first suggestion that a treaty device be used to legalize congressional legislation on migratory game came from Senator Elihu Root of New York. When Eltinge F. Warner became the committee's official mouthpiece in the fight for the preservation of Pribiloff seals, "his magazine was for a time held up in the mail, and intimations were made of possible libel suits, should *Field and Stream* not cease to act for the Committee."

It is perhaps inherent in a movement so complex as conservation that conservationists can never agree completely among themselves. To me, the proud record of the committee is only marred by its resolute position on the management of wolves in Mt. McKinley National Park. Mr. Belt dismisses Adolph Murie's classic 1944 report on the park's ecology as "an elaborate treatise on animal behaviorism" and asserts that "technically trained men without years of field experience are inclined at times to embrace some forceful biological theory which produces disastrous results when applied to wild life in the field." One gathers that the committee not only failed to grasp the complex inner core of population controls in the wild, but it never understood the field background of Dr. Murie as well. Bighorn sheep die-offs in Glacier National Park, Yellowstone, the Pike's Peak area, and the Kenosha and Tarryall ranges of Colorado all testify to the vulnerable position of a sheep population on predatorless range, and to the misguided position that the committee took on wolves in Mt. McKinley National Park. In the realm of straight protection, the committee's work has been outstanding, but its perception of the biological principles of predation has not kept pace with the scientific research of men who have spent their lives on overpopulated big-game ranges.

This negative note is a small one standing in juxtaposition to a striking record of forceful and noble achievements that will add to the beauty and grandeur of New York State and the nation as well for centuries to come. The conservation movement is often full of defeat and disappointment to the individual. Mr. Belt's report should do much to dissipate such an idea: in 47 years, a small group of men, working together, can make posterity their debtors; and this one did!—JOSEPH J. HICKEY, Department of Forestry and Wildlife Management, University of Wisconsin, Madison 6, Wis.

South African Animal Life. Results of the Lund University Expedition in 1950-1951. Volume 2. Edited by Bertil Hanström, Per Brinck, and Gustaf Rudebeck. Almqvist and Wiksell, Stockholm. 576pp., illus. Sw. kr. 68.

This is the second of a projected series of eight volumes. Fourteen authors have contributed 18 chapters (11 in English, five in French, and two in German), of which three deal with arthropods, 14 with insects, and one with birds. The text is based mainly on specimens collected by the Lund University expedition, but some authors have added other material in order to give complete taxonomic reviews of certain groups, sometimes with keys, for all of South Africa; for example, for the Chilopoda, Thysanura, Odonata, Coleoptera: Notiophygidae, and Diptera: Phlebotominae. The chapter on birds is based wholly on a collection of 997 specimens made by the Swedish naturalist Axel W. Ericksson between 1867 and 1890. The Lund University expedition's bird material will be described in a later volume. The present volume is devoted mainly to taxonomy and distribution, although the chapter on Odonata has 12 pages devoted to the ecology of that group.—F. N. HAMERSTROM, JR., Wisconsin Conservation Department, Plainfield, Wis.

CORRECTION

In my discussion of cottontail propagation in small pens (J. Wildl. Mgmt., 21:90), I mentioned the loss of one young rabbit to a least weasel (*Mustela rixosa*). Although I captured this predator at the site of this experiment, I was not at the time aware of the least weasel's actual rarity in eastern Maryland. It now seems advisable to list the weasel as *Mustela* sp.—DALE E. SHEFFER.